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A METHOD FOR AUTOMATIC TEST AND EVALUATION OF MICROWAVE TRANSCE--ETC(U)
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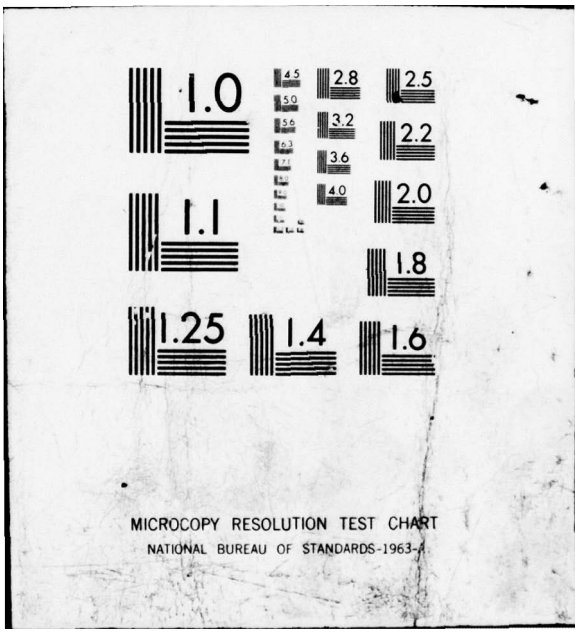
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NRL Memorandum Report 3662

A Method for Automatic Test and Evaluation of Microwave Transceivers at L-Band Frequencies

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Complexity of modern phased array radars requires that new high speed methods of microwave component test and evaluation be devised such that, not only is the specific device under test evaluated as to quality and accuracy, but also in terms of system errors, the total of all devices is evaluated in an appropriate statistical method to assure final use compatibility. This report summarizes the effort at Naval Research Laboratory, Washington, D.C. to devise such a computer controlled laboratory test and evaluation facility capable to measuring not only CW devices, such as receivers, but also pulse devices such as transmitters. More specifically, the program as devised to implement an all

(Continues)

20. Abstract (Continued)

solid state L-band transceiver module evaluation is described.

Samples of computer programs and special test equipment schematics are included along with samples of data printout.

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A METHOD FOR AUTOMATIC TEST AND EVALUATION OF MICROWAVE TRANSCEIVERS AT L-BAND FREQUENCIES

Introduction

The advent of the practical phased array radar introduced the need for complex testing and thorough statistical analysis into the microwave industry. The voluminous quantities of data required on each device coupled with the redundancy of devices used on even a single system made the use of automatic microwave test systems mandatory, not optional.

The long test and evaluation cycle required for acquiring large quantities of data coupled with the uniqueness of each device has in turn created a serious financial burden on most manufacturers who cannot justify the purchase and/or fabrication of such equipment based upon anticipated demands.

The gathering of data on a single device is only the first step in a chain of statistical analyses. Individual limits must be imposed upon each device produced to assure quality control but in a system using hundreds or even thousands of the same device (such as is experienced in phased arrays) then only the aggregate performance is important to the system. Thus through the test of individual devices, system performance can be predicted and as the data base is increased, the importance of individual parameters on the system can develop into higher quality and more cost effective products.

This report describes the effort expended at the Naval Research Laboratory in the attainment of an automatic test facility capable of acquiring individual device data and the reduction of such data into terms suitable for system statistics.

This effort has been concentrated primarily at L-band frequencies and on transmit/receive devices, the latest device being such a transceiver now in production by the General Electric Company, Aircraft Equipment Division, Utica, New York for the Naval Air Development Center, Warminster, Pennsylvania (Dr. J. Smith, Code 2040).

The Device Under Test

In order to reduce the complex testing required to manageable proportions, it is necessary to specifically tailor the test program to the unique device under test and to eliminate operator interaction

Note: Manuscript submitted November 10, 1977.

or reduce this interaction to a minimum. Towards this goal a thorough understanding of the device parameters to be evaluated and the conditions of test is indicated as well as an understanding of microwave testing techniques.

The device that is being considered in this report is a transceiver, used in a phased array radar at L-band, under pulse transmit conditions. In addition to microwave circuitry such as circulators, switches, and amplifiers, the device employs a 5 bit (32 state) electronic phase shifter, and a 3 bit (8 state) electronic step attenuator. Within the transceiver structure is the necessary electronic circuitry to translate incoming digital signals into appropriate performance commands.

It is, therefore, necessary to gather performance data under the following test modes:

transmit
receive
over frequency
over phase
over attenuation (receive only)
over temperature
over supply voltages
over input power (transmit only)

In addition, a typical device may be required to operate under various combinations of PRF and pulse width during transmit which greatly adds to the amount of data required to verify system performance capability.

Referring to the above list the number of data points considered necessary and adequate for the transceiver amounted to 2304 for receive and 864 for transmit for each temperature/voltage combination during acceptance with a total of 20736 receive and 7776 transmitter data points per transceiver module during qualification.

It can therefore be seen that entering into such a test endeavor without an adequate test sequence and plan or without adequate test facilities can lead to chaos.

Microwave Tests. The number and kind of microwave measurements are quite limited but from these limited number of measurements much data can be extracted. In automatic microwave measurement, after appropriate calibration, it is possible to measure

a. Amplitude and angle of reflected power
b. Amplitude and angle of transmitted power

Many systems, such as the Hewlett-Parkcard Automatic Network Analyzer define a set of device S-parameters from which the typical RF terms can be derived. In addition, dependent on the type of device to

be evaluated, it is possible to vary the calibration model and therefore the correction factors applied to the device under test.

In each case, however, the four basic bits of information are used to derive all necessary data. VSWR is derived from the reflective properties. Gain (or loss) is derived from transmission magnitude and such properties as differential phase and differential attenuation are derived from various sets of transmission data. It is insufficient to just derive the S parameter values; it is necessary that data processing be incorporated into any program to permit evaluation.

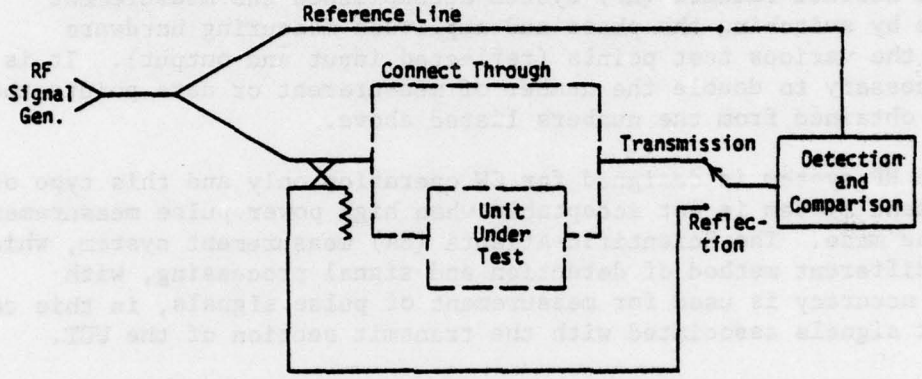


Fig. 1 - Test by comparison test method

The measurement system. Both microwave automatic measurement systems used for the measurements described in this report are similar in method, although quite diverse in design particulars. Referring to Figure 1, the RF signal is divided into two paths, one to be used as a reference, the other as a signal for the unit under test (UUT). In addition, the reflected wave at the input to the UUT is sampled.

To determine a complete set of S parameters, both phase and amplitude of the various signals must be known, first over all measurement frequencies under calibrate conditions with no UUT in the line from which system correction factors are determined and then repeated at the measurement frequencies with the UUT in the line.

The Hewlett-Packard (HP) system accomplishes the measurement sequence by switching the phase and amplitude measuring hardware between the various test points (reflected input and output). It is thus necessary to double the number of measurement or data points that must be obtained from the numbers listed above.

The HP system is designed for CW operation only and this type of measurement system is not acceptable when high power pulse measurements are to be made. The Scientific-Atlanta (SA) measurement system, which uses a different method of detection and signal processing, with reduced accuracy is used for measurement of pulse signals, in this case transmit signals associated with the transmit section of the UUT.

In addition, the Naval Research Laboratory has modified this equipment so that the input power can be leveled at each frequency to predetermined values for evaluation of such devices that are sensitive to input power especially those operating in a non-linear mode (class C transmit operation for the UUT). Also, the addition of pulse peak power meters, to measure forward power before and after the device under test and the input reflected power permits the measruement of powers by sampling (80 nsec) the pulse power. The sampling window can be moved through the RF pulse time and does not operate on the basis of averaging techniques as does the SA equipment.

Transmission and reflection properties of the UUT are measured simultaneously with this equipment, therefore, switching is not required. It is necessary, however, to measure at each data point, a series of five measurements, which are averaged to reduce instantaneous errors and eliminate erroneous measurements. This then means that the number of sequential measurements becomes 80,352 for qualification of each UUT and 8,928 for acceptance.

In addition to the signal measurement hardware, there is associated with the overall control system, a set of control hardware used with the UUT, and redesigned and/or modified as required for each device and test plan that has for its prime function control of the UUT. This control includes the necessary switching of the various module functions

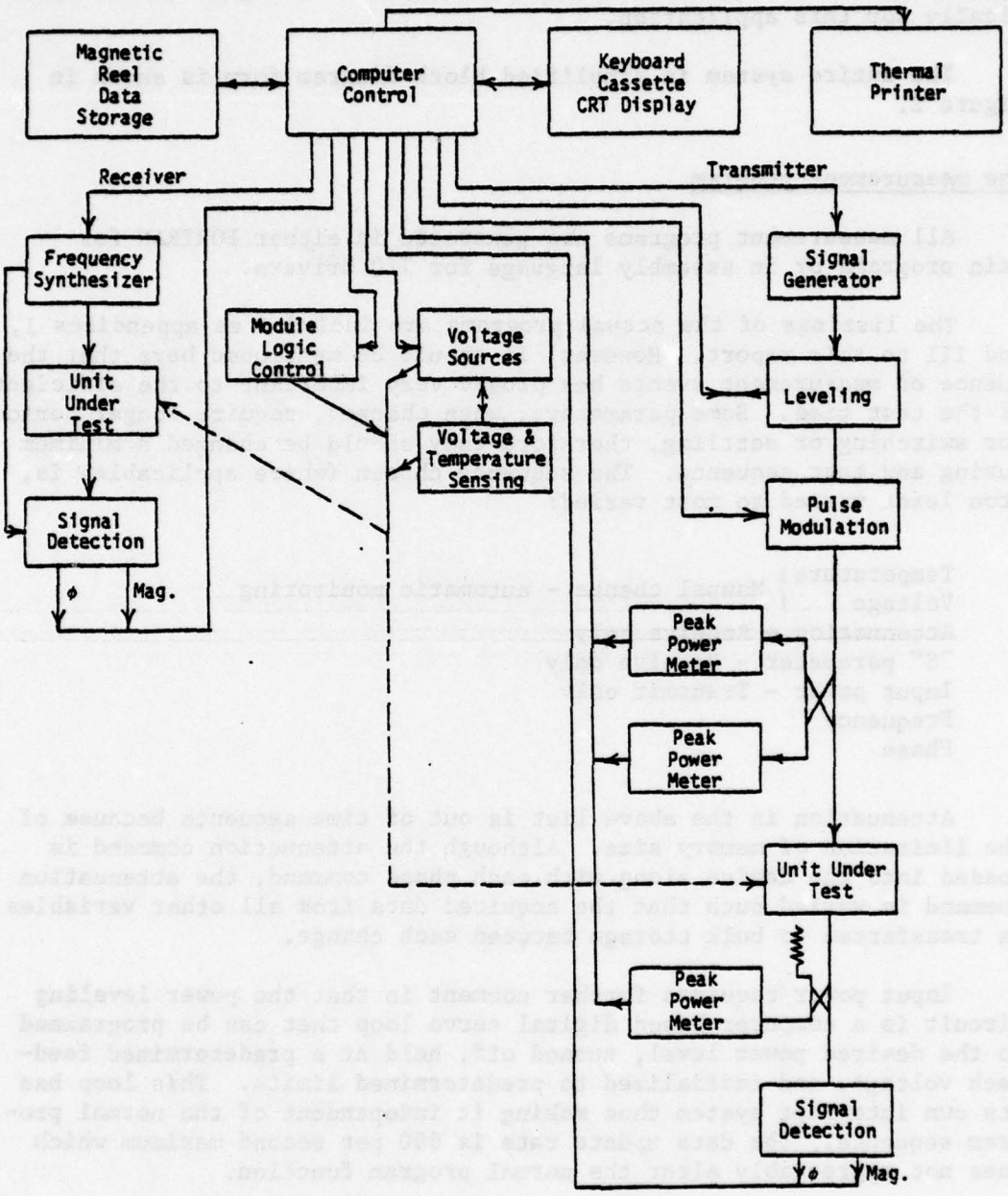


Fig. 2 - Simplified system block diagram

such as transmit/receive, phase shift and attenuation, by the generation of the necessary code sequences under computer control and also the generation and control and/or monitoring of the various supply voltages and operating temperatures. See appendix IV for detail schematics of this special test equipment and other equipments designed at NRL specifically for this application.

The entire system in simplified block diagram form is shown in Figure 2.

The measurement program

All measurement programs are generated in either FORTRAN for main programs or in assembly language for I/0 drivers.

The listings of the actual programs are included as appendices I, II, and III to this report. However, it should be mentioned here that the sequence of measurement events has proved very important to the efficient use of the test time. Some parameters, when changed, require longer periods for switching or settling, therefore they should be changed a minimum during any test sequence. The sequence chosen (where applicable) is, from least varied to most varied:

Temperature, Voltage } Manual change - automatic monitoring
Attenuation - Receive only
"S" parameter - Receive only
Input power - Transmit only
Frequency
Phase

Attenuation in the above list is out of time sequence because of the limitation of memory size. Although the attenuation command is loaded into the device along with each phase command, the attenuation command is varied such that the acquired data from all other variables is transferred to bulk storage between each change.

Input power requires further comment in that the power leveling circuit is a computer based digital servo loop that can be programmed to the desired power level, turned off, held at a predetermined feedback voltage, and initialized to predetermined limits. This loop has its own interrupt system thus making it independent of the normal program sequence. The data update rate is 600 per second maximum which does not appreciably alter the normal program function.

Programs and any other special command functions are entered by way of keyboard or magnetic tape cassette. Data is output to reel type magnetic tape. Each file of data first references a serial number followed

by pertinent test parameters so that a tape can be easily searched for the desired file. The appendices include program listings for searching transmit or receive data tapes, extracting the desired data and processing the data in a similar manner to the main program.

Data processing and output

It is desirable to store the data obtained in raw form on magnetic tape for future processing and generation of overall statistics but it is likewise necessary for immediate use that a summary listing be made available. Many forms could be generated including curves and histograms but the quantity of print-out can rapidly reach uncontrollable proportions.

For this reason it was decided that the raw data as delivered by the test system would be processed into the various specification parameters and presented in tabular form. Because of the statistical nature of the application for the units to be evaluated much of the data is printed out in terms of statistical information.

In addition a keyboard switch option was included in the program that generates a long form print out where in addition to the summary data, information at each frequency-phase state is given. This long form print out is forced when power output under transmit test conditions reaches a level that causes large measurement errors (i.e. 0 dBm) so that the operator is immediately aware of the type of error and then can properly evaluate the statistical parameters.

A listing of the short form print-out is given in Figure 3 and the long form is given in Figure 4.

Conclusions. With the complexity of test and the number of data points necessary for a meaningful statistical analysis, the use of manual test equipment requiring much operator interaction is prohibited.

Thus for production components, or those that are to be produced in quantity where repeated similar tests are to be performed, the computer based test facility with data processing and storage is indicated. Not only can immediate data be obtained but the stored data can be processed at a later date in ways specifically meaningful to the end system use as well as in the form of useful statistics on classes of devices.

```
SER.NO. 001                              RECEIVER
DATE: MAY 20,1977
VOLT1=-11.090                            VOLT2= 23.890
TEMP1=   24.9DEG.C                        TEMP2=  -24.9DEG.C
TAPE TEST, AS CALIBRATED  XXX

ATTNUATION= 2DB.

FREQ.      1235  1260  1280  1295  1300  1305  1320  1340  1365
VSWR MAX   1.04  1.04  1.04  1.04  1.04  1.04  1.05  1.05  1.05
VSWR MEAN  1.04  1.04  1.04  1.04  1.04  1.04  1.05  1.05  1.05
MAX-PH-ER -349. -349. -349. -349. -349. -349. -349. -349. -349.
RMS-PH-ER 203.0 203.0 203.0 203.0 203.0 203.0 203.0 202.9 203.0
MAX-GN-DB    .0    .0    .0   -.0   -.0   -.0   -.0   -.0   -.0
MIN-GN-DB    .0   -.0   -.0   -.0   -.0   -.0   -.0   -.0   -.0
INS PHAS   -18.  -18.  -19.  -19.  -19.  -19.  -19.  -19.  -20.
OVERALL MEAN GAIN=  -.0DB.
STD. DEVIATION IN OVERALL GAIN= -58.3DB.

SER.NO. TEST                             TRANSMITTER
DATE: MAY 17, 1977
VOLT1=-11.145                            VOLT2= 24.150
TEMP1=   23.9DEG.C                        TEMP2=  -34.6DEG.C
NONE

INPUT POWER=24.8DBM.
*FMT #3
FREQ.      1235  1260  1280  1295  1300  1305  1320  1340  1365
VSWR MAX   $$$$$ $$$$$ $$$$$ $$$$$ $$$$$ $$$$$ $$$$$ $$$$$ $$$$$
VSWR MEAN  $$$$$ $$$$$ $$$$$ $$$$$ $$$$$ $$$$$ $$$$$ $$$$$ $$$$$
MAX-PH-ER -349. -349. -349. -304. -259. -349. -349. -349. -349.
RMS-PH-ER 203.0 202.9 202.9 165.6 130.8 203.0 203.0 203.1 203.0
MAX-PWR-W    .0    .0    .0    .0    .0    .0    .0    .0    .0
MIN-PWR-W    .0    .0    .0    .0    .0    .0    .0    .0    .0
INS PHAS      .     .     .     .     .   360.  360.  360.  360.
OVERALL MEAN PEAK POWER=    .0WATTS
STD. DEVIATION IN OVERALL PEAK POWER=    .0WATTS
```

Fig. 3 - Short form printout for transmitter and receiver sections of transceiver

SER.NO. TEST TRANSMITTER

DATE: MAY 17, 1977

VOLT1=-11.145 VOLT2= 24.150

TEMP1= 23.9DEG.C TEMP2= -34.6DEG.C

NONE

INPUT POWER=24.8DBM.

FREQ.	1235	1260	1280	1295	1300	1305	1320	1340	1365
.00 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
IPHS	.	.	.	.	.	360.	360.	360.	360.
11.25 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	-.0	.0	.0	-.0	.0	-.1	-.1
22.50 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.1	.0	.0	.0	-.0	-.0	.0	-.0	-.1
33.75 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.0	.0	.0	.0	.0	.0	.0
45.00 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.1	.0	.0	.0	.0	-.0	-.0
56.25 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.0	.0	-.0	-.0	.0	.0	-.0
67.50 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.1	.0	.0	.0	.0	.0	-.1	-.0	-.1
78.75 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
90.00 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	.0	.0	-.0	.0	-.0	-.0	-.0	-.0	-.1
101.25 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.0	.0	.0	.0	-.0	-.1	-.0
112.50 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.0	.0	.0	-.0	-.0	-.1	-.0
123.75 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.0	.0	.0	.0	-.0	-.1	-.0
135.00 DEG.									
VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	.0	.0	.0	-.0	-.0	.0	-.0	-.1	-.1

Fig. 4 - Long form data printout for transmitter and receiver sections of transceiver module (Continues)

146.25 DEG.

VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.0	.0	.0	-.0	.0	-.1	-.1

157.50 DEG.

VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.0	.0	.0	-.0	-.1	-.2	-.1

168.75 DEG.

VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	-.0	.0	-.0	-.0	-.0	-.2	-.1

180.00 DEG.

VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.1	.0	.0	-.0	.0	.0	-.0	-.2	-.2

191.25 DEG.

VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.0	-.0	.0	-.0	-.0	-.2	-.1

202.50 DEG.

VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.0	.0	.0	-.0	-.0	-.2	-.1

213.75 DEG.

VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	.0	.0	.0	.0	-.0	-.0	-.0	-.2	-.0

225.00 DEG.

VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.0	.0	.0	-.1	-.0	-.2	-.1

236.25 DEG.

VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.0	.0	-.0	-.1	-.0	-.2	.0

247.50 DEG.

VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.1	-.0	.0	.0	-.0	-.2	-.1

258.75 DEG.

VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.1	.0	-.0	.0	.0	.0	.0	-.2	.0

270.00 DEG.

VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.1	.0	360.0	.0	-.0	-.1	-.0

281.25 DEG.

VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.1	.0	-.0	.0	360.0	-.1	.0	-.2	.0

292.50 DEG.

VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	-.0	.0	.0	-.0	360.0	-.0	-.1	-.2	-.1

303.75 DEG.

VSWR	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
MAX-PWR-W	.0	.0	.0	.0	.0	.0	.0	.0	.0
DEL PHASE	.0	.0	.0	-.0	360.0	-.0	.0	-.1	-.0

Fig. 4 (Continued) - Long form data printout for transmitter and receiver sections of transceiver module

SER.NO. 001 . RECEIVER
DATE: MAY 20,1977
VOLT1=-11.090 VOLT2= 23.890
TEMP1= 24.9DEG.C TEMP2= -24.9DEG.C
TAPE TEST, AS CALIBRATED XXX

ATTNUATION= 2DB.

FREQ.	1235	1260	1280	1295	1300	1305	1320	1340	1365
.00 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
IPHS	-18.	-18.	-19.	-19.	-19.	-19.	-19.	-19.	-20.
11.25 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.1	-.0	.0	.0	.0	.0	.0
22.50 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.0	-.0	.0	-.0	.0	.0	.0
33.75 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	.0	-.0	-.1	-.0	-.0	-.0	.0	.0	.0
45.00 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.0	-.0	.0	.0	.0	.0	.0
56.25 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	.0	-.0	-.0	-.0	-.0	-.0	-.0	.0	.0
67.50 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.0	-.0	.0	.0	.0	.0	.0
78.75 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.1	-.0	.0	.0	.0	.0	.0
90.00 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.0	-.0	.0	.0	.0	.0	.0
101.25 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.0	-.0	-.0	.0	.0	.0	.0
112.50 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.1	-.0	.0	-.0	-.0	.0	.0
123.75 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.0	-.0	.0	.0	-.0	.0	.0
135.00 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	.0	-.0	-.0	-.0	-.0	-.0	-.0

Fig. 4 (Continued) - Long form data printout for transmitter and receiver sections of transceiver module

DEL PHASE	-.0	-.0	-.1	-.0	-.0	-.0	.0	.0	.0
146.25 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.0	-.0	-.0	.0	-.0	.0	.0
157.50 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.1	-.0	.0	.0	.0	.0	.0
168.75 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.0	-.0	-.0	.0	-.0	.0	.0
180.00 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.0	-.0	.0	-.0	-.0	.0	.0
191.25 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.1	-.0	.0	.0	.0	.0	.0
202.50 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.1	-.0	.0	-.0	.0	.0	.0
213.75 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.1	-.0	.0	-.0	-.0	.0	.0
225.00 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.1	-.0	-.0	-.0	.0	.0	.0
236.25 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.0	-.0	.0	-.0	-.0	.0	.0
247.50 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	.0	-.0	.0	.0	.0	.0	.0
258.75 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.0	-.0	-.0	-.0	.0	.0	.0
270.00 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.0	-.0	-.0	-.0	.0	.0	.0
281.25 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.1	-.0	-.0	-.0	-.0	.0	.0
292.50 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
DEL PHASE	-.0	-.0	-.1	-.0	-.0	-.0	-.0	.0	.0
303.75 DEG.									
VSWR	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05
GAIN-DB	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0

Fig. 4 (Continued) - Long form data printout for transmitter and receiver sections of transceiver module

```
DEL PHASE    -.0    -.0    -.1    -.0    .0    -.0    .0    -.0    .0
  315.00 DEG.
VSWR         1.04   1.04   1.04   1.04   1.04   1.04   1.05   1.05   1.05
GAIN-DB       .0     .0    -.0    -.0    -.0    -.0    -.0    -.0    -.0
DEL PHASE    -.0    -.0     .0    -.1     .0     .0     .0     .0     .0
  326.25 DEG.
VSWR         1.04   1.04   1.04   1.04   1.04   1.04   1.05   1.05   1.05
GAIN-DB       .0    -.0     .0    -.0    -.0    -.0    -.0    -.0    -.0
DEL PHASE    -.0    -.0    -.0    -.0     .0    -.0     .0     .0     .0
  337.50 DEG.
VSWR         1.04   1.04   1.04   1.04   1.04   1.04   1.05   1.05   1.05
GAIN-DB       .0     .0     .0    -.0    -.0    -.0    -.0    -.0    -.0
DEL PHASE    -.0    -.0    -.0    -.0     .0     .0     .0     .0     .0
  348.75 DEG.
VSWR         1.04   1.04   1.04   1.04   1.04   1.04   1.05   1.05   1.05
GAIN-DB       .0    -.0     .0    -.0    -.0    -.0    -.0    -.0    -.0
DEL PHASE    -.0    -.0    -.0    -.0    -.0     .0    -.0     .0     .0
```

Fig. 4 (Continued) - Long form data printout for transmitter and receiver sections of transceiver module

APPENDIX I

Data processing programs:

These programs are intended for locating data already obtained and stored on magnetic tape. The desired file is called by inputting the serial number and attenuation or input power level. The output processed data is in the form of Figures 3 and 4 of this report.

Appendix I


```
      PROGRAM RDRCV
      DIMENSION NDATE(10),NSER(10),LTL1(20),CM(64,9),GMAG(32,9),
     1GANG(32,9),VMAG(32,9),AMAXV(9),AMENV(9),AMAXP(9),RMSPH(9),
     2DBGMX(9),DBGMI(9),BANG(9),F(9),VANG(32,9),VMG1(288),
     3VAG(288),GAG(288),GNG(288),TEMP8(9),TEMP9(9),ISER(10)
C
C
      EQUIVALENCE (VMAG(1,1),VMG1(1)),(VANG(1,1),VAG(1)),
     1(GMAG(1,1),GAG(1)),(GANG(1,1),GNG(1))
C
C*****************************************************************
C
C     THIS PROGRAM SEARCHES MAG. TAPE FOR DATA WITH MATCHING
C         SERIAL NUMBER AND ATTENUATION.
C     RECEIVER DATA ONLY.
C     OUTPUT DATA TO VERSATEC IN BOTH LONG AND SHORT FORMAT
C         AS PER NADC1.
C
C     REV. C    MAY 20,1977
C     L. LAVEDAN
C
C*****************************************************************
C
      F(1)=1235.
      F(2)=1260.
      F(3)=1280.
      F(4)=1295.
      F(5)=1300.
      F(6)=1305.
      F(7)=1320.
      F(8)=1340.
      F(9)=1365.
C
      CALL CLEAR(0)
      WRITE(9,100)
  100 FORMAT("PROGRAM FOR LOCATING AND PROCESSING RECEIVER"/
     110X," DATA STORED ON MAG. TAPE"//
     2"PLEASE SELECT TAPE AND PUT SYSTEM ON LINE")
C
      CALL PAUSE
      REWIND 18
  110 CALL CLEAR(0)
      WRITE(9,120)
  120 FORMAT("INPUT SERIAL NUMBER←")
      READ(8,130)(ISER(I),I=1,10)
  130 FORMAT(10A2)
      WRITE (9,131)
  131 FORMAT("INPUT ATTENUATION←")
      READ (8,*) NTTN3
  135 READ(18,140)
  140 FORMAT(I1)
      IF(IEOF(18)) 150,135
  150 READ(18,170)LET1,(NSER(I),I=1,10),ITTN3,(NDATE(I),
     1I=1,10),VOLT1,VOLT2,TEMP1,TEMP2,(LTL1(I),I=1,20)
  170 FORMAT(A1,10A2,I2,10A2,2F7.3,2F7.2,20A2)
      IF(IEOF(18))200,210
  210 DO 500 I=1,10
      IF(ISER(I)-NSER(I)) 135,500,135
```

```
  500 CONTINUE
      IF(NTTN3-ITTN3) 135,1000,135
C
C     CORRECT SER NO CONTINUES
C
 1000 READ(18,1001)(VMG1(I),I=1,288)
      READ(18,1001)(VAG(I),I=1,288)
      READ(18,1001)(GAG(I),I=1,288)
      READ(18,1001)(GNG(I),I=1,288)
 1001 FORMAT (28(10E12.7/)10E12.7)
C
C
C
C
C     ORDER PHASE STARTING WITH GANG(1,1)
C
      CALL PHORD(GANG(1,1))
      DO 2060 J=2,9
 2030 IF(GANG(1,J-1)-GANG(1,J)+90.0)2040,2040,2050
 2040 GANG(1,J)=GANG(1,J)-360.0
      GO TO 2030
 2050 CALL PHORD(GANG(1,J))
 2060 CONTINUE
C
C     PROCESS DATA AND PRINT OUT ON VERSATEC
C
C     SET SUM GAIN TO 0
      SUMG=0.0
C     SET SUM(GAIN)↑2 TO 0
      SUMG2=0
C
      DO 2100 II=1,9
C     INITIALIZE VALUES TO FIRST PHASE STATE
      GMAX=GMAG(1,II)
      GMIN=GMAG(1,II)
      VMAX=VMAG(1,II)
      VAVG=VMAX
      PH0=GANG(1,II)
      PHMAX=0.0
      SUMP2=PHMAX
      SUMG=SUMG+GMAG(1,II)
      SUMG2=SUMG2+GMAG(1,II)*GMAG(1,II)
C
C     PHASE LOOP
      DO 2150 IP=2,32
C     DETERMINE REFLECTION COEFF MAX
      IF(VMAG(IP,II)-VMAX) 2070,2070,2065
 2065 VMAX=VMAG(IP,II)
C     DETERMINE SUM REF. COEFF.
 2070 VAVG=VAVG+VMAG(IP,II)
C     DETERMINE VOLTAGE GAIN MAX
      IF (GMAG(IP,II)-GMAX) 2080,2080,2075
 2075 GMAX=GMAG(IP,II)
C     DETERMINE VOLTAGE GAIN MIN
 2080 IF(GMIN-GMAG(IP,II)) 2090,2090,2085
 2085 GMIN=GMAG(IP,II)
C     DETERMINE SUM OF VOLT GAIN
 2090 SUMG=SUMG+GMAG(IP,II)
```

```
C       DETERMINE SUM(VOLT GAIN)↑2
        SUMG2=SUMG2+GMAG(IP,II)*GMAG(IP,II)
C       DETERMINE DELTA PHASE
        DELP=PH0-GANG(IP,II)
C       DETERMINE DELTA PHASE ERROR
        DDELP=DELP-(11.25*FLOAT(IP-1))
C       DETERMINE DEL PHAS ERR MAX
        IF(ABS(DDELP)-ABS(PHMAX)) 2150,2150,2095
 2095   PHMAX=DDELP
C       DETERMINE SUM(DEL PHAS ERR)↑2
        SUMP2 = SUMP2 + DDELP*DDELP
C
 2150   CONTINUE
C       ON A PER FREQ BASIS------
C       CONVERT MAX RHO TO VSWR MAX
        AMAXV(II)=(1.0+VMAX)/(1.0-VMAX)
C       CONVERT AVG RHO TO MEAN VSWR
        AMENV(II)=(1.0+(VAVG/32.0))/(1.0-(VAVG/32.0))
C       CONVERT MAX PHASE
        AMAXP(II)=PHMAX
C       CONVERT RMS PHASE
        RMSPH(II)=SQRT(SUMP2/32.0)
C       CONVERT VOLT GAIN MAX TO MAX GAIN DB
        DBGMX(II)=20.*ALOG(GMAX)/ALOG(10.0)
C       CONVERT VOLT GAIN MIN TO MIN GAIN DB
        DBGMI(II)=20.*ALOG(GMIN)/ALOG(10.0)
C
 2100   CONTINUE
C       CONVERT TO MEAN GAIN
        DBGME=20.*ALOG(SUMG/288.0)/ALOG(10.0)
C       CONVERT TO RMS GAIN
        RMSG=20.*ALOG(SQRT((SUMG2-(SUMG*SUMG/288.0))/288.0))/
       1ALOG(10.0)
C
C
        CALL CLEAR(0)
        WRITE(11,2999)
 2999   FORMAT(10(//))
C
 3000   WRITE(11,3005)(NSER(I),I=1,10)
 3005   FORMAT("SER.NO. ",10A2,5X,"RECEIVER")
        WRITE(11,3010)(NDATE(I),I=1,10)
 3010   FORMAT("DATE: ",10A2)
        WRITE(11,3015)VOLT1,VOLT2
 3015   FORMAT("VOLT1=",F7.3,20X,"VOLT2=",F7.3)
        WRITE(11,3020)TEMP1,TEMP2
 3020   FORMAT("TEMP1=",F7.1,"DEG.C",16X,"TEMP2=",F7.1,"DEG.C")
        WRITE(11,3025)(LTL1(I),I=1,20)
 3025   FORMAT(20A2/)
        WRITE(11,3030)ITTN3
 3030   FORMAT("ATTNUATION=",I2,"DB."/)
        WRITE(11,3035)(F(I),I=1,9)
 3035   FORMAT("FREQ.",3X,9(2X,F4.0))
        WRITE(11,3040)(AMAXV(I),I=1,9)
 3040   FORMAT("VSWR MAX ",9(X,F5.2))
        WRITE(11,3045)(AMENV(I),I=1,9)
 3045   FORMAT("VSWR MEAN",9(X,F5.2))
        WRITE(11,3050)(AMAXP(I),I=1,9)
```

```
 3050 FORMAT("MAX-PH-ER",9(X,F5.1))
      WRITE(11,3055)(RMSPH(I),I=1,9)
 3055 FORMAT("RMS-PH-ER",9(X,F5.1))
      WRITE(11,3060)(DBGMX(I),I=1,9)
 3060 FORMAT("MAX-GN-DB",9(X,F5.1))
      WRITE(11,3065)(DBGMI(I),I=1,9)
 3065 FORMAT("MIN-GN-DB",9(X,F5.1))
      WRITE(11,3070)(GANG(1,I),I=1,9)
 3070 FORMAT("INS PHAS ",9(X,F5.0))
      WRITE(11,3075)DBGME
 3075 FORMAT("OVERALL MEAN GAIN=",F5.1,"DB.")
      WRITE(11,3080)RMSG
 3080 FORMAT("STD. DEVIATION IN OVERALL GAIN=",F6.1,"DB.")
      CALL PAGE
 4005 WRITE(11,3005)(NSER(I),I=1,10)
      WRITE(11,3010)(NDATE(I),I=1,10)
      WRITE(11,3015)VOLT1,VOLT2
      WRITE(11,3020)TEMP1,TEMP2
      WRITE(11,3025)(LTL1(I),I=1,20)
      WRITE(11,3030)ITTN3
      WRITE(11,3035)(F(I),I=1,9)
C
C
      DO 4100 I=1,32
      DO 4101 J=1,9
      TEMP9(J)=(1.+VMAG(I,J))/(1.-VMAG(I,J))
      TEMP8(J)=20.*ALOG(GMAG(I,J))/ALOG(10.0)
 4101 CONTINUE
      BIT=11.25*FLOAT(I-1)
      WRITE(11,4102) BIT
 4102 FORMAT("   ",F6.2," DEG.")
      WRITE (11,4105) (TEMP9(J),J=1,9)
 4105 FORMAT("VSWR",5X,9(X,F5.2))
      WRITE (11,4110) (TEMP8(J),J=1,9)
 4110 FORMAT("GAIN-DB",2X,9(X,F5.1))
      IF(I-1) 4115,4115,4120
 4115 WRITE(11,4125)(GANG(1,J),J=1,9)
 4125 FORMAT("IPHS",5X,9(X,F5.0))
      GO TO 4100
 4120 DO 4126 L=1,9
      BANG(L)=GANG(1,L)-GANG(I,L)
 4126 CONTINUE
      WRITE(11,4130)(BANG(J),J=1,9)
 4130 FORMAT("DEL PHASE",9(X,F5.1))
C
 4100 CONTINUE
      CALL PAGE
C
C
      REWIND 18
      GO TO 110
  200 CALL CLEAR(0)
      WRITE(9,205)
  205 FORMAT("SERIAL NUMBER AND ATTENUATION REQUESTED"
     1" NOT FOUND ON TAPE")
  220 REWIND 18
      CALL PAUSE
      GO TO 110

      END
```

```
      PROGRAM RDXMT
C
      DIMENSION NSER(10),NDATE(10),LTL1(20),TEMP(20),GNG(288),
     1GANG(32,9),GMAG(32,9),AVSWR(32,9),GAG(288),
     2VMG1(288),VMAG(32,9),AMAXV(9),F(9),ISER(10),
     3AMENV(9),AMAXP(9),RMSPH(9),PWRMX(9),PWRMI(9),BANG(9)
C
      EQUIVALENCE (GANG(1,1),GNG(1)),(GMAG(1,1),GAG(1)),
     1(VMAG(1,1),VMG1(1))
C
C*****************************************************************
C
C     THIS PROGRAM SEARCHES MAG. TAPE FOR DATA WITH MATCHING
C     SERIAL NUMBER AND DRIVE POWER.
C
C     TRANSMIT DATA ONLY
C
C     OUTPUTS DATA TO VERSATEC IN BOTH SHORT AND LONG
C     FORMAT AS PER NADC2.
C
C     REV. C    MAY 20,1977
C     L. LAVEDAN
C
C*****************************************************************
C
C
      RHO1=0.11512925
      RHO2=0.23025851
      F(1) = 1235.
      F(2)=1260.
      F(3)=1280.
      F(4)=1295.
      F(5)=1300.
      F(6)=1305.
      F(7)=1320.
      F(8)=1340.
      F(9)=1365.
C
      CALL CLEAR(0)
      WRITE(9,100)
  100 FORMAT("PROGRAM FOR LOCATING AND PROCESSING TRANSMITTER"/
     16X," DATA STORED ON MAG. TAPE"//
     2"PLEASE SELECT TAPE AND PUT SYSTEM ON LINE")
C
      CALL PAUSE
      REWIND 18
  110 CALL CLEAR(0)
      WRITE(9,120)
  120 FORMAT("INPUT SERIAL NUMBER←")
      READ(8,130)(ISER(I),I=1,10)
  130 FORMAT(10A2,F4.1)
      WRITE (9,131)
  131 FORMAT ("INPUT DRIVE LEVEL (23.8,24.8,25.8)←")
      READ (8,*) PWRB
  135 READ(18,140)
  140 FORMAT(I1)
      IF(IEOF(18)) 150,160
  160 GO TO 135
```

```
  150 READ(18,170)LET1,(NSER(I),I=1,10),PWRA,(NDATE(I),
     1I=1,10),VOLT1,VOLT2,TEMP1,TEMP2,(LTL1(I),I=1,20)
  170 FORMAT(A1,10A2,F4.1,10A2,2F7.3,2F7.2,20A2)
      IF(IEOF(18))200,210
  210 DO 500 I=1,10
      IF(ISER(I)-NSER(I)) 135,500,135
  500 CONTINUE
      IF(PWRA-PWRB) 135,1000,135
C
C     CORRECT SER NO CONTINUES
C
 1000 READ(18,1001)(VMG1(I),I=1,288)
      READ(18,1001)(GAG(I),I=1,288)
      READ(18,1001)(GNG(I),I=1,288)
 1001 FORMAT (28(10E12.7/)10E12.7)
C
      IFLG = 0
C
C     ORDER PHASE STARTING WITH GANG(1,1)
C     PORD ORDERS POSITIVE PHASE DELAY
      CALL PORD(GANG(1,1))
      DO 1240 J=2,9
 1225 IF(GANG(1,J-1)-GANG(1,J)-90.0) 1235,1230
 1230 GANG(1,J)=GANG(1,J)+360.0
      GO TO 1225
 1235 CALL PORD(GANG(1,J))
 1240 CONTINUE
C
C
      SUMG=0.0
      SUMG2=0.0
C     FREQ LOOP
      DO 1600 II=1,9
C
C     INITIALIZE VALUES TO PHASE STATE
      GMAX=GMAG(1,II)
      IF (GMAG(1,II))1298,1299,1298
 1299 IFLG=1
 1298 GMIN=GMAX
      VMAX=VMAG(1,II)
      VAVG=VMAX
      PH0=GANG(1,II)
      PHMAX=0.0
      SUMP2=PHMAX
      SUMG=SUMG+GMAG(1,II)
      SUMG2=SUMG2+GMAG(1,II)*GMAG(1,II)
C
C     PHASE LOOP
      DO 1335 IP=2,32
      IF(GMAG(IP,II))1301,1302,1301
 1302 IFLG=1
 1301 IF(VMAG(IP,II)-VMAX) 1305,1305,1300
 1300 VMAX=VMAG(IP,II)
 1305 VAVG=VAVG+VMAG(IP,II)
      IF(GMAG(IP,II)-GMAX) 1315,1315,1310
 1310 GMAX=GMAG(IP,II)
 1315 IF(GMIN-GMAG(IP,II)) 1325,1325,1320
 1320 GMIN=GMAG(IP,II)
```

```
 1325 SUMG=SUMG+GMAG(IP,II)
      SUMG2=SUMG2+(GMAG(IP,II))*(GMAG(IP,II))
      DELP=GANG(IP,II)-PH0
      DDELP=DELP-(11.25*FLOAT(IP-1))
      IF(ABS(DDELP)-ABS(PHMAX)) 1335,1335,1330
 1330 PHMAX=DDELP
      SUMP2=SUMP2+DDELP*DDELP
 1335 CONTINUE
C
C
C     ON A PER FREQ BASIS
C     CONVERT MAX RHO TO VSWR MAX
      AMAXV(II)=(1.0+VMAX)/(1.0-VMAX)
C     CONVERT AVG RHO TO MEAN VSWR
      AMENV(II)=(1.0+(VAVG/32.0))/(1.0-(VAVG/32.0))
C     CONVERT MAX PHASE
      AMAXP(II)=PHMAX
C     CONVERT RMS PHASE
      RMSPH(II)=SQRT(SUMP2/32.0)
      PWRMX(II)=GMAX
      PWRMI(II)=GMIN
 1600 CONTINUE
C
C     MEAN POWER
      PWRME=SUMG/288.0
C     RMS POWER
      RMSPW=SQRT((SUMG2/288.0)-(PWRME*PWRME))
C
C     PRINT SEQUENCE---SHORT FORM
C
      CALL CLEAR(0)
      WRITE(11,2999)
 2999 FORMAT(10(//))
C
 3000 WRITE(11,3005)(NSER(I),I=1,10)
 3005 FORMAT("SER.NO. ",10A2,5X,"TRANSMITTER")
      WRITE(11,3010)(NDATE(I),I=1,10)
 3010 FORMAT("DATE: ",10A2)
      WRITE(11,3015)VOLT1,VOLT2
 3015 FORMAT("VOLT1=",F7.3,20X,"VOLT2=",F7.3)
      WRITE(11,3020)TEMP1,TEMP2
 3020 FORMAT("TEMP1=",F7.1,"DEG.C",16X,"TEMP2=",F7.1,"DEG.C")
      WRITE(11,3025)(LTL1(I),I=1,20)
 3025 FORMAT(20A2/)
      WRITE(11,3030)PWRA
 3030 FORMAT("INPUT POWER=",F4.1,"DBM.")
      IF(IFLG) 3031,3034,3031
 3031 WRITE(11,3032)
 3032 FORMAT ("CAUTION--ERRORS ENCOUNTERED IN DATA")
 3034 WRITE (11,3033)
 3033 FORMAT ("  ")
      WRITE(11,3035)(F(I),I=1,9)
 3035 FORMAT("FREQ.",3X,9(2X,F4.0))
      WRITE(11,3040)(AMANV(I),I=1,9)
 3040 FORMAT("VSWR MAX ",9(X,F5.2))
      WRITE(11,3045)(AMENV(I),I=1,9)
 3045 FORMAT("VSWR MEAN",9(X,F5.2))
      WRITE(11,3050)(AMAXP(I),I=1,9)
```

```
 3050 FORMAT("MAX-PH-ER",9(X,F5.1))
      WRITE(11,3055)(RMSPH(I),I=1,9)
 3055 FORMAT("RMS-PH-ER",9(X,F5.1))
      WRITE(11,3060)(PWRMX(I),I=1,9)
 3060 FORMAT("MAX-PWR-W",9(X,F5.1))
      WRITE(11,3065)(PWRMI(I),I=1,9)
 3065 FORMAT("MIN-PWR-W",9(X,F5.1))
      WRITE(11,3070)(GANG(1,I),I=1,9)
 3070 FORMAT("INS PHAS ",9(X,F5.0))
      WRITE(11,3075)PWRME
 3075 FORMAT("OVERALL MEAN PEAK POWER=",F5.1,"WATTS")
      WRITE(11,3080)RMSPW
 3080 FORMAT("STD. DEVIATION IN OVERALL PEAK POWER=",F5.1,
     1"WATTS")
C
      CALL PAGE
C
 4005 WRITE(11,3005)(NSER(I),I=1,10)
      WRITE(11,3010)(NDATE(I),I=1,10)
      WRITE(11,3015)VOLT1,VOLT2
      WRITE(11,3020)TEMP1,TEMP2
      WRITE(11,3025)(LTL1(I),I=1,20)
      WRITE(11,3030)PWRA
      WRITE(11,3035)(F(I),I=1,9)
      DO 4100 I=1,32
      DO 4101 J=1,9
      VMAG(I,J)=(1.0+VMAG(I,J))/(1.0-VMAG(I,J))
 4101 CONTINUE
      BIT=11.25*FLOAT(I-1)
      WRITE(11,4102) BIT
 4102 FORMAT("   ",F6.2," DEG.")
      WRITE(11,4105)(VMAG(I,J),J=1,9)
 4105 FORMAT("VSWR",5X,9(X,F5.2))
      WRITE(11,4110)(GMAG(I,J),J=1,9)
 4110 FORMAT("MAX-PWR-W",9(X,F5.1))
      IF(I-1) 4115,4115,4120
 4115 WRITE(11,4125)(GANG(1,J),J=1,9)
 4125 FORMAT("IPHS",5X,9(X,F5.0))
      GO TO 4100
 4120 DO 4126 L=1,9
      BANG(L)=GANG(I,L)-GANG(1,L)
 4126 CONTINUE
      WRITE(11,4130)(BANG(J),J=1,9)
 4130 FORMAT("DEL PHASE",9(X,F5.1))
C
 4100 CONTINUE
      CALL PAGE
      REWIND 18
      GO TO 110
  200 CALL CLEAR(0)
      WRITE(9,205)
  205 FORMAT("SERIAL NUMBER AND DRIVE POWER REQUESTED"
     1" NOT FOUND ON TAPE")
  220 REWIND 18
      CALL PAUSE
      GO TO 110
      END
```

APPENDIX II

Data acquisition programs:

NADC 1 and 2 are the two primary programs employed in hardware control and data acquisition, processing, and storage for the transceiver modules described in this report.

CALS1 is a transmitter test subroutine used in the hardware calibration sequence.

BORIS is a receiver test subroutine for calibration of the Hewlett Packard network analyzer and is similar to that used by Newlett Packard except that it is tailored specifically to module test.

```
      PROGRAM NADC1
      DIMENSION NDATE(10),NSER(10),LTL1(20),CM(64,9),GMAG(32,9),
     1GANG(32,9),VMAG(32,9),AMAXV(9),AMENV(9),AMAXP(9),RMSPH(9),
     2DBGMX(9),DBGMI(9),BANG(9),F(9),VANG(32,9),VMG1(288),
     3VAG(288),GAG(288),GNG(288),TEMP8(9),TEMP9(9)
C
      COMMON LT1ST,LT2ND,LTSTP,LINFR,LINND,EXT(3),IS(2),
     1IDMY,LCAL,ICTYP,INEW,FCO,CAL(6,9)
C
      EQUIVALENCE (VMAG(1,1),VMG1(1)),(VANG(1,1),VAG(1)),
     1(GMAG(1,1),GAG(1)),(GANG(1,1),GNG(1))
C
C*****************************************************************
C
C  THIS IS A SPECISL MEASUREMENT PROGRAM FOR
C  MEASURING THE REFLECTION AND TRANSMISSION BEFORE OUTPUTING
C  DATA TO MAGNETIE TAPE.
C
C
C
C     BORIS SHELEG   10 MARCH77
C     REV M          18 MAY 77
C
C         THIS IS MODIFIED GPM1
C
C*****************************************************************
C
C  INITIALIZE FLAGS--FIRST TIME ONLY--AND CONSTANTS
C
      CALL CLRIO
C
C     TRAP 1 IS RETURN TO MEASURE
      CALL TRAP(1)
      GO TO 1000
C     TRAP 2 IS RETURN TO CALIBRATE
      CALL TRAP(2)
      GO TO 50
   50 CALL CLEAR(0)
C
      WRITE(9,80)
   80 FORMAT("PUT DATA TAPE ON DECK AND ON LINE")
      CALL PAUSE
      WRITE(9,85)
   85 FORMAT("NEW TAPE (Y OR N)=←")
      CALL NYES(IV)
      IF(IV) 99,90
   90 ENDFILE 18
      ENDFILE 18
      REWIND 18
   99 CONTINUE
      WRITE(9,100)
  100 FORMAT("DATE:",20X,"↑,10↑↑"←")
      READ(8,105)(NDATE(I),I=1,10)
  105 FORMAT(10A2)
C
C     ENTER FREQUENCIES IN MHZ HERE
C
      F(1)=1235
```

```
      F(2)=1260
      F(3)=1280
      F(4)=1295
      F(5)=1300
      F(6)=1305
      F(7)=1320
      F(8)=1340
      F(9)=1365
C
C
      CALL BORIS(F(1))
C
 1000 CALL CLEAR(0)
      WRITE(9,1005)
 1005 FORMAT("SER.NO.=",20X,"↑,10↑↑"←")
      READ(8,1007)(NSER(I),I=1,10)
 1007 FORMAT(10A2)
      WRITE(9,1010)
 1010 FORMAT("REMARKS:",40X,"↑,20↑↑"←")
      READ(8,1012)(LTL1(I),I=1,20)
 1012 FORMAT(20A2)
      WRITE(9,1015)
 1015 FORMAT("CONNECT DEVICE------")
      CALL BELL
      CALL PAUSE
C
C
C     MEASUREMENT CYCLE--DATA RETURNED IN CM ARRAY
C
      DO 4000 ITTN=1,8
C
C     CHAN 1=TEMP DEG C
C     CHAN 2=TEMP DEG C
C     CHAN 4=40 VOLT
C     CHAN 5=12 VOLT
C
      CALL TVOLD(1,TEMP1)
      CALL TVOLD(2,TEMP2)
      CALL TVOLD(4,VOLT1)
      CALL TVOLD(5,VOLT2)
C
C     SET ATTENUATION
      ITTN2=ITTN-1
C
      CALL SETPH(0,ITTN2)
C
C     CALL MEASURE AT 9 FREQ AND 32 PHASES
C
      CALL MCOR1(F(1),CM)
C
C     OUTPUT DATA TO MAG TAPE
C
C     CONVERT CM ARRAY TO MAG AND ANGLE
C
 2000 DO 2020 J=1,9
      DO 2020 I=1,32
      GANG(I,J)=ANG(CM(2*I,J))
      GMAG(I,J)=CMAG(CM(2*I,J))
```

```
      VMAG(I,J)=CMAG(CM(2*I-1,J))
      VANG(I,J)=ANG(CM(2*I-1,J))
 2020 CONTINUE
      ITTN3=ITTN2*2
C
C     FIND END OF TAPE
C
 2021 READ(18,2022)
 2022 FORMAT(I1)
      IF(IEOF(18)) 2023,2021
 2023 READ(18,2022)
      IF(IEOF(18)) 2024,2021
 2024 BACKSPACE 18
C
C     PUT TITLE INFO ON TAPE
C
      WRITE(18,2025)(NSER(I),I=1,10),ITTN3,(NDATE(I),
     1I=1,10),VOLT1,VOLT2,TEMP1,TEMP2,(LTL1(I),I=1,20)
C
C     PUT MEASURED DATA ON TAPE
C
 2025 FORMAT("R",10A2,I2,10A2,2F7.3,2F7.2,20A2)
      WRITE(18,2027)(VMG1(I),I=1,288)
      WRITE(18,2027)(VAG(I),I=1,288)
      WRITE(18,2027)(GAG(I),I=1,288)
      WRITE(18,2027)(GNG(I),I=1,288)
 2027 FORMAT(28(10E12.7/)10E12.7)
C
C     ORDER PHASE STARTING WITH GANG(1,1)
C
      CALL PHORD(GANG(1,1))
      DO 2060 J=2,9
 2030 IF(GANG(1,J-1)-GANG(1,J)+90.0)2040,2040,2050
 2040 GANG(1,J)=GANG(1,J)-360.0
      GO TO 2030
 2050 CALL PHORD(GANG(1,J))
 2060 CONTINUE
C
C     PROCESS DATA AND PRINT OUT ON VERSATEC
C     SW 1 IS QUAL LONG FORM OPTION
C
C     SET SUM GAIN TO 0
      SUMG=0.0
C     SET SUM(GAIN)↑2 TO 0
      SUMG2=0
C
      DO 2100 II=1,9
C     INITIALIZE VALUES TO FIRST PHASE STATE
      GMAX=GMAG(1,II)
      GMIN=GMAG(1,II)
      VMAX=VMAG(1,II)
      VAVG=VMAX
      PH0=GANG(1,II)
      PHMAX=0.0
      SUMP2=PHMAX
      SUMG=SUMG+GMAG(1,II)
      SUMG2=SUMG2+GMAG(1,II)*GMAG(1,II)
C
```

```
C       PHASE LOOP
        DO 2150 IP=2,32
C       DETERMINE REFLECTION COEFF MAX
        IF(VMAG(IP,II)-VMAX) 2070,2070,2065
 2065   VMAX=VMAG(IP,II)
C       DETERMINE SUM REF. COEFF.
 2070   VAVG=VAVG+VMAG(IP,II)
C       DETERMINE VOLTAGE GAIN MAX
        IF (GMAG(IP,II)-GMAX) 2080,2080,2075
 2075   GMAX=GMAG(IP,II)
C       DETERMINE VOLTAGE GAIN MIN
 2080   IF(GMIN-GMAG(IP,II)) 2090,2090,2085
 2085   GMIN=GMAG(IP,II)
C       DETERMINE SUM OF VOLT GAIN
 2090   SUMG=SUMG+GMAG(IP,II)
C       DETERMINE SUM(VOLT GAIN)↑2
        SUMG2=SUMG2+GMAG(IP,II)*GMAG(IP,II)
C       DETERMINE DELTA PHASE
        DELP=PH0-GANG(IP,II)
C       DETERMINE DELTA PHASE ERROR
        DDELP=DELP-(11.25*FLOAT(IP-1))
C       DETERMINE DEL PHAS ERR MAX
        IF(ABS(DDELP)-ABS(PHMAX)) 2150,2150,2095
 2095   PHMAX=DDELP
C       DETERMINE SUM(DEL PHAS ERR)↑2
        SUMP2 = SUMP2 + DDELP*DDELP
C
 2150   CONTINUE
C       ON A PER FREQ BASIS------
C       CONVERT MAX RHO TO VSWR MAX
        AMAXV(II)=(1.0+VMAX)/(1.0-VMAX)
C       CONVERT AVG RHO TO MEAN VSWR
        AMENV(II)=(1.0+(VAVG/32.0))/(1.0-(VAVG/32.0))
C       CONVERT MAX PHASE
        AMAXP(II)=PHMAX
C       CONVERT RMS PHASE
        RMSPH(II)=SQRT(SUMP2/32.0)
C       CONVERT VOLT GAIN MAX TO MAX GAIN DB
        DBGMX(II)=20.*ALOG(GMAX)/ALOG(10.0)
C       CONVERT VOLT GAIN MIN TO MIN GAIN DB
        DBGMI(II)=20.*ALOG(GMIN)/ALOG(10.0)
C
 2100   CONTINUE
C       CONVERT TO MEAN GAIN
        DBGME=20.*ALOG(SUMG/288.0)/ALOG(10.0)
C       CONVERT TO RMS GAIN
        RMSG=20.*ALOG(SQRT((SUMG2-(SUMG*SUMG/288.0))/288.0))/
       1ALOG(10.0)
C
C       PRINT SEQUENCE--SHORT FORM
C
        CALL CLEAR(0)
        WRITE(11,2999)
 2999   FORMAT(10(//))
C
 3000   WRITE(11,3005)(NSER(I),I=1,10)
 3005   FORMAT("SER.NO. ",10A2,5X,"RECEIVER")
        WRITE(11,3010)(NDATE(I),I=1,10)
```

```
 3010 FORMAT("DATE: ",10A2)
      WRITE(11,3015)VOLT1,VOLT2
 3015 FORMAT("VOLT1=",F7.3,20X,"VOLT2=",F7.3)
      WRITE(11,3020)TEMP1,TEMP2
 3020 FORMAT("TEMP1=",F7.1,"DEG.C",16X,"TEMP2=",F7.1,"DEG.C")
      WRITE(11,3025)(LTL1(I),I=1,20)
 3025 FORMAT(20A2/)
C
      ITTN1=(ITTN-1)*2
      WRITE(11,3030)ITTN1
 3030 FORMAT("ATTNUATION=",I2,"DB."/)
      WRITE(11,3035)(F(I),I=1,9)
 3035 FORMAT("FREQ.",3X,9(2X,F4.0))
      WRITE(11,3040)(AMAXV(I),I=1,9)
 3040 FORMAT("VSWR MAX ",9(X,F5.2))
      WRITE(11,3045)(AMENV(I),I=1,9)
 3045 FORMAT("VSWR MEAN",9(X,F5.2))
      WRITE(11,3050)(AMAXP(I),I=1,9)
 3050 FORMAT("MAX-PH-ER",9(X,F5.1))
      WRITE(11,3055)(RMSPH(I),I=1,9)
 3055 FORMAT("RMS-PH-ER",9(X,F5.1))
      WRITE(11,3060)(DBGMX(I),I=1,9)
 3060 FORMAT("MAX-GN-DB",9(X,F5.1))
      WRITE(11,3065)(DBGMI(I),I=1,9)
 3065 FORMAT("MIN-GN-DB",9(X,F5.1))
      WRITE(11,3070)(GANG(1,I),I=1,9)
 3070 FORMAT("INS PHAS ",9(X,F5.0))
      WRITE(11,3075)DBGME
 3075 FORMAT("OVERALL MEAN GAIN=",F5.1,"DB.")
      WRITE(11,3080)RMSG
 3080 FORMAT("STD. DEVIATION IN OVERALL GAIN=",F6.1,"DB.")
C
C     PUT PROCESSED DATA ON TAPE WITH ENDFILES
C
      CALL PAGE
      WRITE(18,3090)(AMAXV(I),I=1,9)
      WRITE(18,3090)(AMENV(I),I=1,9)
      WRITE(18,3090)(AMAXP(I),I=1,9)
      WRITE(18,3090)(RMSPH(I),I=1,9)
      WRITE(18,3090)(DBGMX(I),I=1,9)
      WRITE(18,3090)(DBGMI(I),I=1,9)
      WRITE(18.3090)(GANG(1,I),I=1,9)
      WRITE(18,3090)DBGME,RMSG
 3090 FORMAT(9E13.7)
      ENDFILE 18
      ENDFILE 18
      BACKSPACE 18
      BACKSPACE 18
C
C
C
C
C     SW 1 UP=LONG FORM FOR QUAL
      IF(ISP(1)) 4005,4006
 4005 WRITE(11,3005)(NSER(I),I=1,10)
      WRITE(11,3010)(NDATE(I),I=1,10)
      WRITE(11,3015)VOLT1,VOLT2
      WRITE(11,3020)TEMP1,TEMP2
```

```
      WRITE(11,3025)(LTL1(I),I=1,20)
      WRITE(11,3030)ITTN1
      WRITE(11,3035)(F(I),I=1,9)
C
C
      DO 4100 I=1,32
      DO 4101 J=1,9
      TEMP9(J)=VSWRC(CM(2*I-1,J))
      TEMP8(J)=DBC(CM(2*I,J))
 4101 CONTINUE
      BIT=11.25*FLOAT(I-1)
      WRITE(11,4102) BIT
 4102 FORMAT("  ",F6.2," DEG.")
      WRITE (11,4105) (TEMP9(J),J=1,9)
 4105 FORMAT("VSWR",5X,9(X,F5.2))
      WRITE (11,4110) (TEMP8(J),J=1,9)
 4110 FORMAT("GAIN-DB",2X,9(X,F5.1))
      IF(I-1) 4115,4115,4120
 4115 WRITE(11,4125)(GANG(1,J),J=1,9)
 4125 FORMAT("IPHS",5X,9(X,F5.0))
      GO TO 4100
 4120 DO 4126 L=1,9
      BANG(L)=GANG(1,L)-GANG(I,L)
 4126 CONTINUE
      WRITE(11,4130)(BANG(J),J=1,9)
 4130 FORMAT("DEL PHASE",9(X,F5.1))
C
 4100 CONTINUE
      CALL PAGE
 4000 CONTINUE
      GO TO 1000
      END
```

```
      PROGRAM NADC2
C
      DIMENSION NSER(10),NDATE(10),LTL1(20),TEMP(20),GNG(288),
     1GANG(32,9),GMAG(32,9),AVSWR(32,9),GAG(288),
     2VMG1(288),VMAG(32,9),AMAXV(9),
     3AMENV(9),AMAXP(9),RMSPH(9),PWRMX(9),PWRMI(9),BANG(9)
C
      COMMON F(9),PIMC(9),POMC(9),PVSWR(9),S2PMC(9),SAFMC(9)
C
      EQUIVALENCE (GANG(1,1),GNG(1)),(GMAG(1,1),GAG(1)),
     1(VMAG(1,1),VMG1(1))
C
C*****************************************************************
C
C     THIS PROGRAM CALIBRATES THE S.A. EQUIPMENT AND PERFORMS
C     THE NADC MEASUREMENT SEQUENCE.
C     INPUT COUPLER AND/OR PAD INFO IS NECESSARY.
C     INPUT, REFLECTED AND TRANSMITTED POWERS ARE MEASURED
C     USING SHORT WINDOW PEAK POWER METERS. THE WINDOWS CAN
C     BE MANUALLY MOVED THRU THE PULSE. AUTOMATIC INPUT
C
C     POWER LEVELING IS USED WHICH IS PROGRAMABLE.
C     A MAX OF 30 SAMPLES IS TAKEN AT EACH TEST CONDITION
C     AND IF 5 ARE NOT FOUND ACCEPTABLE FOR AVERAGING,
C     THEN PROGRAM GIVES ZEROS AND PROCEEDS.EQUIPMENT PULSES
C     IN STANDBY UNTIL OPERATOR GIVES OK FOR TEMPERATURE
C     STABILITY. PULSES ARE REMOVED BY HARDWARE WHEN
C     FREQ/VOLT/PHASE/POWERIN CHANGES ARE IN PROGRESS.
C     HARD COPY AND MAG TAPE OUTPUT.
C
C     SW 1 UP FOR QUAL. LONG FORM OUTPUT.
C
C     REV. H    5/17/77
C
C     L.LAVEDAN      4/20/77
C
C*****************************************************************
C
C     SET S.A. INTERFACE
      CALL SETIP
C     SET UP PULSE GENERATOR
      CALL SPULG(1,30,10,5,64)
C     SET TO NOMINAL INPUT POWER
      CALL INITP(-6.0)
C
      RHO1=0.11512925
      RHO2=0.23025851
C     DEFINE FREQUENCY SEQUENCE
      F(1)=1235
      F(2)=1260
      F(3)=1280
      F(4)=1295
      F(5)=1300
      F(6)=1305
      F(7)=1320
      F(8)=1340
      F(9)=1365
C     SET FREQUENCY TO MIN BAND
```

```
      CALL SETFR(F(5))
C     TURN OFF OUTPUT POWER
      CALL OPULG
C
C     TRAP 1 IS RETURN TO MEASURE
      CALL TRAP(1)
      GO TO 1000
C
C     TRAP 2 IS RETURN TO CALIBRATION
      CALL TRAP(2)
      GO TO 50
C
   10 CALL CLEAR(0)
      WRITE(9,12)
   12 FORMAT(21X,"***S.A. TEST PROGRAM***"//"READ COUPLER"
     1" INFO FROM TAPE?←")
      CALL NYES(ITC)
      IF(ITC) 14,16
C
C     GET COUPLING INFO FROM KEYBOARD
C
   14 WRITE(9,18)
   18 FORMAT("TYPE IN THE FOLLOWING COUPLINGS"/"FREQ.  INPUT"
     1" COUP.(+DB)   OUTPUT COUP.(+DB)")
      DO 20 I=1,9
      WRITE(9,22)F(I)
   22 FORMAT(F8.1,":←")
      READ(8,*)PIMC(I),POMC(I)
   20 CONTINUE
      GO TO 50
C
   16 WRITE(9,24)
   24 FORMAT("POSITION TAPE IN DECK #2")
      CALL PAUSE
      READ(14,*)(PIMC(J),POMC(J),J=1,9)
      WRITE(9,28)(F(I),PIMC(I),POMC(I),I=1,9)
   28 FORMAT(9(3F10.2/))
C
   50 CALL CLEAR(0)
C
C     MAKE SURE POWER LOOP IS STILL ON
C
      CALL PLRST
      WRITE(9,80)
   80 FORMAT("PUT MAG TAPE FOR DATA IN DECK AND ON LINE")
      CALL PAUSE
      WRITE(9,85)
   85 FORMAT("NEW TAPE (Y OR N)=←")
      CALL NYES(IV)
      IF(IV) 99,90
   90 ENDFILE 18
      ENDFILE 18
      REWIND 18
   99 CONTINUE
C
      WRITE(9,25)
   25 FORMAT("DATE:",20X,"↑,10Y)"←")
      READ(8,30)NDATE
```

```
   30 FORMAT(20A2)
C
      PMIN=23.8
      PNOM=24.8
      PMAX=25.8
C
C     CALIBRATION SEQUENCE
C
  100 CALL CLEAR(0)
      CALL CALS1
 1000 CALL OPULG
      CALL PLRST
C
      WRITE(9,1005)
 1005 FORMAT("SER.NO.="20X,"↑,10↑Y"←")
      READ(8,30)(NSER(I),I=1,10)
      WRITE(9,1010)
 1010 FORMAT("REMARKS:"40X,"↑,20↑Y"←")
      READ(8,30)(LTL1(I),I=1,20)
      WRITE(9,1015)
 1015 FORMAT("CONNECT DEVICE AND THERMOCOUPLE(1) TO DEVICE"/
     1"AND PUT SWITCH 2 DOWN")
      CALL BELL
      CALL PAUSE
C     SET PHASE AND AMPLITUDE
      CALL SETPH(0,0)
C     RESTORE PULSE GENERATOR
      CALL RPULG
C     TURN ON AT F(5) AND PNOM
      POWER=PNOM-PIMC(5)
      CALL SETPW(POWER)
      CALL SETFR(F(5))
C
      CALL CLEAR(0)
C
      WRITE(9,1020)
 1020 FORMAT("PUT UP SWITCH 2 FOR EXIT FROM TEMP. LOOP")
C     TEMPERATURE LLOP---CHAN 1 ON DEVICE
      DO 1035 I=1,20
      CALL TVOLD(1,TEMP(I))
      WRITE(9,1025)TEMP(I)
 1025 FORMAT(F7.2)
      IF(ISP(2)) 1060,1030
 1030 CALL DELAY(5000)
 1035 CONTINUE
 1037 DO 1040 I=1,19
      TEMP(I)=TEMP(I+1)
 1040 CONTINUE
      CALL TVOLD(1,TEMP(20))
      CALL CLEAR(0)
      WRITE(9,1020)
      WRITE(9,1045)(TEMP(I),I=1,20)
 1045 FORMAT(20(F7.2/))
      IF(ISP(2)) 1060,1050
 1050 CALL DELAY(5000)
      GO TO 1037
C     START MEASUREMENTS
C     POWER INPUT LOOP
```

```
C
C
 1060 DO 4000 IPL=1,3
      IFLG = 0
      DELPW=2-IPL
      PWRA=26.8-FLOAT(IPL)
      CALL CLEAR(0)
      WRITE(9,1065)PWRA
 1065 FORMAT("MEASUREING FOR POWER LEVEL OF",F5.1,"DBM.")
C
C
C     CHAN1=TEMP DEG.C OF MODULE
C     CHAN2=TEMP DEG.C
C     CHAN4=40 VOLT
C     CHAN5=12 VOLT
C
      CALL TVOLD(1,TEMP1)
      CALL TVOLD(2,TEMP2)
      CALL TVOLD(4,VOLT1)
      CALL TVOLD(5,VOLT2)
C     BEGIN FREQUENCY LOOP
      DO 1200 IFR=1,9
      POWER=PWRA-PIMC(IFR)
      CALL SETPW(POWER)
      CALL SETFR(F(IFR))
C
C     INITIATE A DELAY AND THROW FIRST DATA OUT
C
      CALL SETPH (0,0)
      CALL R5DAT(A1,A2,F1,A3,A4)
C
C     BEGIN PHASE LOOP
      DO 1200 IBT=1,32
      IBT1=IBT-1
      CALL SETPH(IBT1,0)
 1080 CALL R5DAT(A1,A2,F1,A3,A4)
      IF (A2) 1085,1089,1085
 1085 TMP=ABS(A2-S2PMC(IFR)-DELPW)
      IF(TMP-.3) 1090,1070
 1070 WRITE(9,1075)TMP
 1075 FORMAT("REF.CHAN.DIFF.=",F8.2,"DB. --ACCEPT IT?←")
      CALL NYES(ITC)
      IF(ITC) 1080, 1090
C
 1089 IFLG = 1
 1090 TMP=F1-SAFMC(IFR)
 1095 IF(TMP) 1100,1105
 1100 TMP=TMP+360.0
      GO TO 1095
 1105 IF(TMP-360.0) 1115,1110
 1110 TMP=TMP-360.0
      GO TO 1105
 1115 GANG(IBT,IFR)=TMP
      TEMP3=-A3+POMC(IFR)-30.0
      GMAG(IBT,IFR)=EXP(RHO2*TEMP3)
      TEMP3=-A4+PVSWR(IFR)
      VMAG(IBT,IFR)=EXP(RHO1*(TEMP3-PWRA))
C
```

```
 1200 CONTINUE
C
      POWER=PWRA-PIMC(1)
      CALL SETPW(POWER)
      CALL SETFR(F(1))
C
C     OUTPUT DATA TO MAG TAPE
C     FIND END OF TAPE
C
 2021 READ(18,2022)
 2022 FORMAT(I1)
      IF(IEOF(18)) 2023,2021
 2023 READ(18,2022)
      IF(IEOF(18)) 2024,2021
 2024 BACKSPACE 18
C
C     PUT TITLE INFO ON TAPE
C
      WRITE(18,2025)(NSER(I),I=1,10),PWRA,(NDATE(I),
     1I=1,10),VOLT1,VOLT2,TEMP1,TEMP2,(LTL1(I),I=1,20)
 2025 FORMAT("T",10A2,F4.1,10A2,2F7.3,2F7.2,20A2)
C
C     PUT MEASURED DATA ON TAPE
C
      WRITE(18,2027)(VMG1(I),I=1,288)
      WRITE(18,2027)(GAG(I),I=1,288)
      WRITE(18,2027)(GNG(I),I=1,288)
 2027 FORMAT(28(10E12.7/)10E12.7)
C
C
C     ORDER PHASE STARTING WITH GANG(1,1)
C     PORD ORDERS POSITIVE PHASE DELAY
      CALL PORD(GANG(1,1))
      DO 1240 J=2,9
 1225 IF(GANG(1,J-1)-GANG(1,J)-90.0) 1235,1230
 1230 GANG(1,J)=GANG(1,J)+360.0
      GO TO 1225
 1235 CALL PORD(GANG(1,J))
 1240 CONTINUE
C
C
      SUMG=0.0
      SUMG2=0.0
C     FREQ LOOP
      DO 1600 II=1,9
C
C     INITIALIZE VALUES TO PHASE STATE
      GMAX=GMAG(1,II)
      GMIN=GMAX
      VMAX=VMAG(1,II)
      VAVG=VMAX
      PH0=GANG(1,II)
      PHMAX=0.0
      SUMP2=PHMAX
      SUMG=SUMG+GMAG(1,II)
      SUMG2=SUMG2+GMAG(1,II)*GMAG(1,II)
C
C     PHASE LOOP
```

```
      DO 1335 IP=2,32
      IF(VMAG(IP,II)-VMAX) 1305,1305,1300
 1300 VMAX=VMAG(IP,II)
 1305 VAVG=VAVG+VMAG(IP,II)
      IF(GMAG(IP,II)-GMAX) 1315,1315,1310
 1310 GMAX=GMAG(IP,II)
 1315 IF(GMIN-GMAG(IP,II)) 1325,1325,1320
 1320 GMIN=GMAG(IP,II)
 1325 SUMG=SUMG+GMAG(IP,II)
      SUMG2=SUMG2+(GMAG(IP,II))*(GMAG(IP,II))
      DELP=GANG(IP,II)-PH0
      DDELP=DELP-(11.25*FLOAT(IP-1))
      IF(ABS(DDELP)-ABS(PHMAX)) 1335,1335,1330
 1330 PHMAX=DDELP
      SUMP2=SUMP2+DDELP*DDELP
 1335 CONTINUE
C
C
C     ON A PER FREQ BASIS
C     CONVERT MAX RHO TO VSWR MAX
      AMAXV(II)=(1.0+VMAX)/(1.0-VMAX)
C     CONVERT AVG RHO TO MEAN VSWR
      AMENV(II)=(1.0+(VAVG/32.0))/(1.0-(VAVG/32.0))
C     CONVERT MAX PHASE
      AMAXP(II)=PHMAX
C     CONVERT RMS PHASE
      RMSPH(II)=SQRT(SUMP2/32.0)
      PWRMX(II)=GMAX
      PWRMI(II)=GMIN
 1600 CONTINUE
C
C     MEAN POWER
      PWRME=SUMG/288.0
C     RMS POWER
      RMSPW=SQRT((SUMG2/288.0)-(PWRME*PWRME))
C
C     PRINT SEQUENCE---SHORT FORM
C
      CALL CLEAR(0)
      WRITE(11,2999)
 2999 FORMAT(10(//))
C
 3000 WRITE(11,3005)(NSER(I),I=1,10)
 3005 FORMAT("SER.NO. ",10A2,5X,"TRANSMITTER")
      WRITE(11,3010)(NDATE(I),I=1,10)
 3010 FORMAT("DATE: ",10A2)
      WRITE(11,3015)VOLT1,VOLT2
 3015 FORMAT("VOLT1=",F7.3,20X,"VOLT2=",F7.3)
      WRITE(11,3020)TEMP1,TEMP2
 3020 FORMAT("TEMP1=",F7.1,"DEG.C",16X,"TEMP2=",F7.1,"DEG.C")
      WRITE(11,3025)(LTL1(I),I=1,20)
 3025 FORMAT(20A2/)
      WRITE(11,3030)PWRA
 3030 FORMAT("INPUT POWER=",F4.1,"DBM.")
      IF(IFLG) 3031,3034,3031
 3031 WRITE(11,3032)
 3032 FORMAT ("CAUTION--ERRORS ENCOUNTERED IN DATA")
 3034 WRITE (11,3033)
```

```
 3033 FORMAT ("   ")
      WRITE(11,3035)(F(I),I=1,9)
 3035 FORMAT("FREQ.",3X,9(2X,F4.0))
      WRITE(11,3040)(AMAXV(I),I=1,9)
 3040 FORMAT("VSWR MAX ",9(X,F5.2))
      WRITE(11,3045)(AMENV(I),I=1,9)
 3045 FORMAT("VSWR MEAN",9(X,F5.2))
      WRITE(11,3050)(AMAXP(I),I=1,9)
 3050 FORMAT("MAX-PH-ER",9(X,F5.1))
      WRITE(11,3055)(RMSPH(I),I=1,9)
 3055 FORMAT("RMS-PH-ER",9(X,F5.1))
      WRITE(11,3060)(PWRMX(I),I=1,9)
 3060 FORMAT("MAX-PWR-W",9(X,F5.1))
      WRITE(11,3065)(PWRMI(I),I=1,9)
 3065 FORMAT("MIN-PWR-W",9(X,F5.1))
      WRITE(11,3070)(GANG(1,I),I=1,9)
 3070 FORMAT("INS PHAS ",9(X,F5.0))
      WRITE(11,3075)PWRME
 3075 FORMAT("OVERALL MEAN PEAK POWER=",F5.1,"WATTS")
      WRITE(11,3080)RMSPW
 3080 FORMAT("STD. DEVIATION IN OVERALL PEAK POWER=",F5.1,
     1"WATTS")
C
C     PUT PROCESSED DATA ON TAPE
C     WITH ENDFILES
      CALL PAGE
      WRITE(18,3090)(AMAXV(I),I=1,9)
      WRITE(18,3090)(AMENV(I),I=1,9)
      WRITE(18,3090)(AMAXP(I),I=1,9)
      WRITE(18,3090)(RMSPH(I),I=1,9)
      WRITE(18,3090)(PWRMX(I),I=1,9)
      WRITE(18,3090)(PWRMI(I),I=1,9)
      WRITE(18,3090)(GANG(1,I),I=1,9)
      WRITE(18,3090)PWRME,RMSPW
 3090 FORMAT(9E13.7)
      ENDFILE 18
      ENDFILE 18
      BACKSPACE 18
      BACKSPACE 18
C
C     SW 1 UP= LONG FORM FOR QUAL
      IF (IFLG) 4005,4004,4005
 4004 IF(ISP(1)) 4005,4000
 4005 WRITE(11,3005)(NSER(I),I=1,10)
      WRITE(11,3010)(NDATE(I),I=1,10)
      WRITE(11,3015)VOLT1,VOLT2
      WRITE(11,3020)TEMP1,TEMP2
      WRITE(11,3025)(LTL1(I),I=1,20)
      WRITE(11,3030)PWRA
      WRITE(11,3035)(F(I),I=1,9)
      DO 4100 I=1,32
      DO 4101 J=1,9
      VMAG(I,J)=(1.0+VMAG(I,J))/(1.0-VMAG(I,J))
 4101 CONTINUE
      BIT=11.25*FLOAT(I-1)
      WRITE(11,4102) BIT
 4102 FORMAT("   ",F6.2," DEG.")
      WRITE(11,4105)(VMAG(I,J),J=1,9)
```

```
 4105 FORMAT("VSWR",5X,9(X,F5.2))
      WRITE(11,4110)(GMAG(I,J),J=1,9)
 4110 FORMAT("MAX-PWR-W",9(X,F5.1))
      IF(I-1) 4115,4115,4120
 4115 WRITE(11,4125)(GANG(1,J),J=1,9)
 4125 FORMAT("IPHS",5X,9(X,F5.0))
      GO TO 4100
 4120 DO 4126 L=1,9
      BANG(L)=GANG(I,L)-GANG(1,L)
 4126 CONTINUE
      WRITE(11,4130)(BANG(J),J=1,9)
 4130 FORMAT("DEL PHASE",9(X,F5.1))
C
 4100 CONTINUE
      CALL PAGE
 4000 CONTINUE
      CALL SETFR(F(5))
      CALL SETPW(-6.0)
      CALL OPULG
C
      GO TO 1000
      END
```

```
      SUBROUTINE CALS1
      COMMON F(9),PIMC(9),POMC(9),PVSWR(9),S2PMC(9),
     1$AFMC(9),
C*****************************************************************
C
C     CALIBRATION ROUTINE FOR S.A. NADC PROGRAM
C     INCLUDING VSWR  AND VERIFICATION
C
C     REV.A     APR.21,1977
C
C*****************************************************************
C
C     INITIAL SETUP
C
   10 CALL SPULG(1,30,10,5,16)
      POWER=24.8-PIMC(5)
      CALL SETPW(POWER)
      CALL SETFR(F(5))
      WRITE(9,110)
  110 FORMAT("ADJUST POWER LEVEL FOR ZERO VOLTS")
      CALL BELL
      CALL PAUSE
      POWER=26.8-PIMC(5)
      CALL SETPW(POWER)
      WRITE(9,100)
  100 FORMAT("MAX. GAIN OF MODULE (DB):←")
      READ(8,*)GMAX
      GMAX=-GMAX-2.0
      WRITE(9,120) GMAX
  120 FORMAT("ADJUST RECEIVER GAINS AS FOLLOWS:"/
     1  "REF. CHANNEL... -2.0 DB."/
     2  "TEST CHANNEL "F8.1" DB"/"TO CONTINUE, LIFT SWITCH 8")
  130 CALL RAPHD(A1,A2,F1,A3,A4)
      IF(ISP(8)) 140,130
  140 CALL R5DAT(A1,A2,F1,A3,A4)
      WRITE(9,150)
  150 FORMAT("PUT SWITCH 8 DOWN")
      CALL BELL
  160 IF(ISP(8)) 160,165
  165 CALL SPULG(1,30,10,5,64)
      CALL DELAY(20)
      CALL R5DAT(A11,A21,F1,A3,A4)
      TMP=-20.91515
      A1=A1+TMP
      A2=A2+TMP
      WRITE(9,170) A1,A2,A11,A21
  170 FORMAT("TEST AMPLITUDE READINGS WERE:"
     1  /"EXPECTED: TEST CHANNEL="F6.1"  REF. CHANNEL="F6.1
     2  /"MEASURED: TEST CHANNEL="F6.1"  REF. CHANNEL="F6.1
     3  /"OK TO CONTINUE?←")
      CALL NYES(ITC)
      IF(ITC) 10,200
  200 CALL CLEAR(0)
      DO 220 I=1,9
  210 CALL SETFR(F(I))
      POWER=24.8-PIMC(I)
      CALL SETPW(POWER)
      CALL DELAY(20)
```

```
      CALL R5DAT(A1,S2PMC(I),SAFMC(I),A3,A4)
  220 CONTINUE
  240 CALL SETFR(F(1))
      POWER=24.8-PIMC(1)
      WRITE (9,250)
  250 FORMAT ("VERIFY CALIBRATION?←")
      CALL NYES(ITC)
      IF (ITC) 290,260
  260 DO 280  I = 1, 9
      POWER = 24.8-PIMC(I)
      CALL SETFR(F(I))
      CALL SETPW(POWER)
      CALL DELAY(20)
      CALL R5DAT(A1,A2,F1,A3,A4)
      A2=A2-S2PMC(I)
      F1=F1-SAFMC(I)
 1000 IF (F1) 1001,1005
 1001 F1 = F1 + 360.0
      GO TO 1000
 1005 IF (F1-360.0) 1010,1006
 1006 F1 = F1 - 360.0
      GO TO 1005
 1010 A3 = -A3 + POMC(I)
      WRITE (9,270) F(I),A2,F1,A3
  270 FORMAT(4F10.2)
  280 CONTINUE
      GO TO 240
  290 CALL CLEAR(0)
      WRITE (9,300)
  300 FORMAT ("CONNECT SYSTEM AS FOLLOWS:"/
     1 "VSWR POWER METER TO VSWR PORT"/
     2 "SHORT ON MODULE/HI-POWER PORT AT END OF CABLE")
      CALL PAUSE
      DO 350  I = 1, 9
      POWER = 24.8 - PIMC(I)
      CALL SETFR(F(I))
      CALL SETPW(POWER)
      CALL DELAY(20)
      CALL R1DAT(A4)
C     SVSWR(I) IS TO BE SUBTRACTED FROM A4 DURING MEASUREMENT
      PVSWR(I) = 24.8 + A4
  350 CONTINUE
      CALL CLEAR(0)
      CALL SETFR(F(5))
      CALL SETPW(-6.0)
      END
```

```
      SUBROUTINE BORIS(F)
      DIMENSION F(2),C(6),IC(12),CAL(6,2),TEM(2,9)
      COMMON ID(11),IS(2),I1(3),INEW,FCO,ICAL(12,2)
      EQUIVALENCE (C,IC),(CAL,ICAL)
C
C*****************************************************************
C     THIS IS A ONE PATH CALIBRATION
C     6 PARAMETER ERROR MODEL
C     CALLED BY BORIS(F)
C     WHERE F IS START FREQUENCY ARRAY
C     INEW IS FLAG TO TRAP CALL, SET TO - AT END
C     OF NORMAL CALIBRATION
C
C     BORIS SHEHEG  MAR. 4,1977
C     REV I         APR 26,1977
C
C     THIS IS MODIFIED CALB1
C
C*****************************************************************
C
C     INITIALIZE AND DEFINE CONSTANTS
C
C     DEFINE S11 AND S21 FOR COMMON AND MCOR1
      IS(1)=11
      IS(2)=21
C
      F1=F(1)
      CALL FCALF(F1)
      CALL BCNT1(F1)
      CALL CPAK2(1.0,0.0,C1)
C
C     MEASURE LOADS
C
C
   75 CALL SSEL1(11)
      M=1
      MN=1
      IP=1
C
C
  110 KOP=3
      WRITE(2,905)
  905 FORMAT("PORT 1: CONNECT FEMALE SMA LOAD")
      CALL PAUSE
      GO TO 9000
C
C
C     MEASURE CROSSTALK
C
  200 CALL FREQ2(F1)
      WRITE(2,908)
  908 FORMAT("CONNECT FEMALE SMA LOADS, TWO PORTS FOR ISOL.")
      CALL SSEL1(21)
      CALL PAUSE
      IP=5
      KOP=4
      M=1
      GO TO 9000
```

```
C
C
C       TEST FOR DESTINATION
C
C       MEASURE SHORTS
C
  305 CALL SSEL1(11)
      CALL FREQ2(F1)
      IP=2
      KOP=5
  310 WRITE(2,913)
  913 FORMAT("PORT 1: CONNECT SMA FEMALE SHORT")
      CALL PAUSE
      M=1
      GO TO 9000
C
C
C       MEASURE OPEN
C
C
  400 M=1
      IP=3
      KOP=6
  430 CALL FREQ2(F1)
C
C
  480 WRITE(2,930)
  930 FORMAT("PORT 1: CONNECT SMA FEMALE OPEN")
      CALL PAUSE
      GO TO 9000
C
C
  550 RAD=2.0*ATAN(0.032*FL*3.14159E-4)
      T3=1.0
C
  560 CALL CSUB2(C(1),C(2),T1)
      CALL CSUB2(C(3),C(1),T2)
      CALL PSFT2(0.0,T3,RAD,T2,T3)
C
  580 CALL CSUB2(T3,T1,T3)
C
      CALL CADD2(T2,T1,T4)
      CALL CDIV2(T3,T4,T5)
      CALL CADD2(C1,T5,T3)
      CALL CMPY2(T3,T1,C(2))
      C(3)=T5
      GO TO 9250
C
C
C       CONNECT THRU S11 AND S21
C
 1005 WRITE(2,935)
  935 FORMAT("CONNECT THRU FEMALE/FEMALE SMA ADAPTER")
      CALL FREQ2(F1)
      CALL PAUSE
      M=1
C
C
```

```
C       REFLECTION
C
 1010 IP=6
      KOP=7
      GO TO 9000
C
C
C       TRANSMISSION
C
 1500 IP=4
      KQP=8
      M=M2
      CALL SSEL1(21)
      GO TO 9000
C
 1030 RL1=1.22
      T4=RL1*4.193E-4
      CALL CSUB2(C(6),C(1),T1)
      CALL CMPY2(T1,C(3),T2)
      CALL CADD2(T2,C(2),T2)
      CALL CDIV2(T1,T2,C(6))
      CALL PSFT2(0.0,FL,T4,C(6),C(6))
      GO TO 9250
C
C
 1130 T3=RL1*2.0965E-4
      CALL CSUB2(C(4),C(5),T1)
      CALL CMPY2(C(3),C(6),T2)
      CALL PSFT2(0.0,FL,T4,T2,T2)
      CALL CSUB2(C1,T2,T2)
      CALL CMPY2(T2,T1,C(4))
      CALL PSFT2(0.0,FL,T3,C(4),C(4))
      GO TO 9250
C
C
C       RETURN TO MAIN PROGRAM
C
C
 2000 CALL FREQ2(F1)
      INEW=-1
 1170 CALL CLEAR(0)
 1172 WRITE(9,1175)
 1175 FORMAT("VERIFY CALIBRATION(Y OR N)?←")
      CALL NYES(N1)
      IF(N1) 1180,1185
 1185 CALL CLEAR(0)
      WRITE(9,1190)
 1190 FORMAT("CONNECT THRU---")
      CALL PAUSE
C
C       VERIFICATION MEASUREMENT SEQUENCE
C
      CALL BCNT1(F(1))
      CALL SSEL1(11)
      DO 1200 I=1,9
      CALL FREQ2(F(I))
      CALL MEAS1(500,V1,V2)
      CALL CPAK2(V1,V2,V1)
```

```
      CALL CSUB2(V1,CAL(1,I),V1)
      CALL CDIV2(V1,CAL(2,I),V2)
      CALL CMPY2(V2,CAL(3,I),V1)
      CALL CADD2(C1,V1,V1)
      CALL CDIV2(V2,V1,TEM(1,I))
 1200 CONTINUE
      CALL SSEL1(21)
      DO 1210 I=1,9
      CALL FREQ2(F(I))
      CALLMEAS1(500,V1,V2)
      CALL CPAK2(V1,V2,V1)
      CALL CSUB2(V1,CAL(5,I),V1)
      CALL CDIV2(V1,CAL(4,I),V2)
      CALL CMPY2(TEM(1,I),CAL(3,I),V1)
      CALL CSUB2(C1,V1,V1)
      CALL CMPY2(V1,V2,TEM(2,I))
 1210 CONTINUE
C
      CALL CLEAR(0)
      DO 1220 I=1,9
      TE1=CMAG(TEM(1,I))
      TE2=ANG(TEM(1,I))
      TE3=CMAG(TEM(2,I))
      TE4=ANG(TEM(2,I))
      WRITE(9,1222)F(I),TE1,TE2,TE3,TE4
 1222 FORMAT(F4.0,4(5X,F9.3))
 1220 CONTINUE
      GO TO 1172
 1180 CALL CLEAR(0)
      CALL FREQ2(F(1))
      RETURN
C
C
C
C     TEST LOOP************************
C
C
 9000 NAVEC=-5
      CRA=0.2
      CALL CPAK2(CRA,0.0,CRA)
 9010 FN=F(M)
      IT1=-1
      M2=M
      CALL FREQ2(FN)
C
 9100 MN=M+1
      FL=FN
      FN=F(MN)
C
C
 9130 CALL MEAS1(100,T1,T2)
      IF(9-MN) 9552,9150
 9552 IT1=1
      GO TO 9140
 9150 CALL FREQ2(FN)
C
 9140 CALL CPAK2(T1,T2,T1)
      IF(NAVEC+5) 9220,9220,9200
```

```
 9200 CALL CADD2(CAL(IP,M),T1,T1)
 9220 CAL(IP,M)=T1
      IF(NAVEC+1) 9300,9230
 9230 CALL CMPY2(CRA,T1,CAL(IP,M))
           DO 9240 N=1,12
 9240            IC(N)=ICAL(N,M)
                 GO TO(9300,200,9300,9300,9300,550,1030,1130)KOP
 9250      DO 9260 N=1,12
 9260            ICAL(N,M)=IC(N)
C
 9300 IF(IT1) 9320,9310
 9320 M=MN
      GO TO 9100
 9310 NAVEC=NAVEC+1
      IF(NAVEC) 9330,9920
 9330 M=M2
      GO TO 9010
C
C
 9920 GOTO(200,200,200,305,400,1005,1500,2000)KOP
C
C
      END
```

APPENDIX III

IO Drivers:

MCOR1 is a driver for calling the various microwave equipments necessary for an actual receiver measurement. It is similar to a Hewlett Packard program by the same name but has been tailored specifically for receiver module measurements. It includes a call to set the phase (and amplitude) of the receiver.

SIGDR is a four entry subroutine that controls and levels the transmitter input power on an interrupt basis.

SETPH is a subroutine used to control the phase and attenuation settings of the module for both transmit and receive.

```
      NAM MCOR1
      ENT MCOR1
      EXT .ENTR,FREQ2,MEAS1,CPAK2,CADD2,CMPY2,CDIV2
      EXT CSUB2,SSEL1,BCNT1,FLOAT,NBNDF,SETPH
      COM DMY1(11),IS(2),DMY2(6),CAL
*
*****************************************************************
*  MAKES CORRECTED MEASUREMENTS OF TRANSMISSION AND
*  REFLECTION. ACCESS FREQUENCY THRU ARRAY PASSED THRU
*  MAIN PROGRAM
*  FORM OF CALL FROM FORTRAN IS: CALL MCOR1(F1ST,CM)
*  WHERE F1ST IS THE STARTING ADDRESS OF THE FREQUENCY ARRAY
*  STORED IN THE CALLING PROGRAM. AND CM IS THE CORRECTED
*  DATA ARRAY.
*
*  IS(1)=11  AND IS(2)=21
*
*  CM ARRAY=CM(64,9)
*
*  REV. D   APR  25, 1977
*
*  MARCH 15, 1977      B. SHELEG
*****************************************************************
*
*
F1ST  NOP
CM    NOP
*                        DATA ARRAY ADDR
MCOR1 NOP
      JSB .ENTR
      DEF F1ST
*
      JSB BCNT1          BEAM CENTER
      DEF *+2
      DEF F1ST,I
*
*
      CLA,INA
      STA M
      LDA S1DEF          IP=INDERECT THRU S1
      STA IP
      CLA
      STA ITR            FULL REF. AND TRANS.
*
*
*  SCAN FOR S11    (IP PRESET)
*
A1    JSB SSEL1          SELECT REFLECTION
      DEF *+2
      DEF IS
      LDA CDI
      STA ATA1
      INA
      STA ATA2
      JSB AT1            START MEASUREMENT
*
*
*  MEASURE S21
```

```
*
A2      ISZ IP          S21
        NOP
        CCA
        STA ITR         FLAG ITR=-1
        LDA CDI         SET UP TRACKING
        ADA THRE        AND LEAKAGE CAL ADDRESSES
        STA ATA2
        INA
        STA ATA1
        JSB SSEL1       S21
        DEF *+2
        DEF IS+1
        JSB AT1         START MEASUREMENT SCAN
*
*
A10     JSB FREQ2       RESET TO FIRST FREQ
        DEF *+2
        DEF F1ST,I
        JMP MCOR1,I
*
*
* CORRECTION FOR REFLECTION
CORR    JSB CMPY2
        DEF *+4
        DEF C3,I
        DEF S1,I
        DEF T1
        JSB CADD2
        DEF *+4
        DEF CONE
        DEF T1
        DEF T1
        JSB CDIV2
        DEF *+4
        DEF S1,I        S1=T11/(1+T11*E11)
        DEF T1
        DEF S1,I
*
*
*   CORRECTION TO S21 FOR SOURCE MATCH ERROR
*
        JSB CMPY2       D=1-S1*E11
        DEF *+4
        DEF S1,I
        DEF C3,I
        DEF T1
        JSB CSUB2
        DEF *+4
        DEF CONE
        DEF T1
        DEF T1
        JSB CMPY2       S21=T1*T21
        DEF *+4
        DEF T1
        DEF S2,I
        DEF S2,I
        JMP AT8
```

```
*
*
*  TEST LOOP
*
AT1     NOP             ENTRY POINT
        JSB FREQ2       SET FIRST FREQUENCY
        DEF *+2
        DEF F1ST,I
        LDA DLY1        SET LONG DELAY
        STA IDLY
        CLA             SET FIRST PHASE
        STA P
        JSB SETPH
        DEF *+2
        DEF P
        CLA
        STA IT1         NOT LAST FREQ
        CCA
        STA IT3         NEED NEW CALIB DATA
        CLA,INA
        STA M           SET M=FIRST FREQ
*
*
        JMP AT3
*
AT2     LDA M           SET UP NEXT FREQ
        INA
        STA MN
        CMA,INA
        ADA NINE
        STA IT1         IF IT1<0 DOING LAST FREQ
        SSA
        JMP AT3         LAST FREQ--DONT SET NEW
        LDA M           M=MN-1
        ALS
        ADA F1ST        ADDRESS OF FREQ
        STA IFN         SAVE ADDRESS
*
*
AT3     LDA P           SET UP NEXT PHASE
        INA
        STA P
        CMA,INA
        ADA D31
        STA IT2         SET LAST PHASE FLAG
        SSA,RSS         YES--NEXT PHASE IS ZERO
        JMP AT4
        CLA
        STA P
*
*
AT4     JSB MEAS1       READ VOLTAGES
        DEF *+4
        DEF IDLY
        DEF T1
        DEF T2
        JSB SETPH       SET NEXT PHASE
        DEF *+2
```

```
        DEF P
        LDA DLY3        SET SHORT DELAY
        STA IDLY
        LDA IT2
        SSA,RSS         TEST FOR LAST PHASE
        JMP AT5         NO, NO NEW FREQ
        LDA IT1         WAS LAST FREQ?
        SSA
        JMP AT5         YES, NO NEW FREQ
        JSB FREQ2       NO, SET NEW FREQ
        DEF *+2
IFN     NOP
        LDA DLY2        SET MED DELAY
        STA IDLY
        LDA M1          SET NEW CALIB FLAG
        STA IT3
        JMP AT51        SKIP NEW CAL SECTION
*
AT5     LDA IT3
        SSA,RSS         NEED NEW CALIB?
        JMP AT51        NO
        LDA M
        MPY TWLV
        ADA CALD        CALIB ADDER -12
        LDB MSIX
        STB CNTR
        LDB CDEF
        STA 1,I         STORE POINTERS
        ADA TWO
        INB
        ISZ CNTR
        JMP *-4
        CCA             -1 TO A
        ADA M
        MPY ON28
        ADA CM          GET DATA SDDRESS
        STA S1
        ADA TWO
        STA S2
        CLA             SET NEW CALIB FLAG TO NO
        STA IT3
*
*
AT51    JSB CPAK2       PACK DATA
        DEF *+4
        DEF T1
        DEF T2
        DEF T1
        JSB CSUB2       SUBTRACT LEAKAGE
        DEF *+4
        DEF T1
ATA1    NOP
        DEF T1
        JSB CDIV2       DIVIDE BY TRACKING
        DEF *+4
        DEF T1
ATA2    NOP
        DEF IP,I        STORE IN CM
```

```
        LDB ITR
        SSB
        JMP CORR        RETURN FOR CORRECTION
*
AT8     LDA S1
        ADA FOUR        UPDATE STORAGE
        STA S1
        ADA TWO
        STA S2
        LDA IT2
        SZA,RSS         LAST PHASE?
        JMP AT2         YES--SET UP NEW FREQ
        SSA,RSS         FREQ DONE?
        JMP AT3         NO--SET UP NEXT PHASE
        LDA MN          STARTING NEW FREQ
        STA M
        LDA IT1
        SSA,RSS         ALL DONE?
        JMP AT3         NO NEXT PHASE
        CLA,INA
        STA M           SET UP M AGAIN
        JMP AT1,I
*
*  VARIABLES
*
*
M       NOP
IP      NOP
T1      BSS 2
T2      BSS 2
MN      NOP
ITR     NOP
*  T11,T22 USE C1,C2,C4,C5
CNTR    NOP
IDLY    NOP
IT1     NOP
IT2     NOP
IT8     NOP
P       NOP
C1      NOP
C2      NOP
C3      NOP
C4      NOP
C5      NOP
C6      NOP
S1      NOP
S2      NOP
*
*
*  CONSTANTS
M1      DEC -1
TWO     DEC 2
THRE    DEC 3
FOUR    DEC 4
S1DEF   DEF S1,I
CONE    OCT 40000       COMPLEX ONE
        OCT 2
DLY1    DEC 500
```

```
DLY2    DEC  100
DLY3    DEC  1
D31     DEC  31
ON28    DEC  128
TWLV    DEC  12
CALD    DEF  CAL-14B
MSIX    DEC  -6
CDEF    DEF  C1
CDI     DEF  C1,I
B1      DEC  -36
NINE    DEC  9
*
*
        END
```

```
       NAM SETPH
       ENT SETPH
       EXT .ENTR
*
*
*****************************************************************
*      8500 BCS COMPATABLE PHASE AND AMPLITUDE
*      CONTROL ROUTING
*
*                    MARCH 21,1977
*                    M. B. LAING
*                    REV. A    MAY 11, 1977
*
*      CALLING SEQUENCE
*      CALL SETPH(IPHASE,IATTN)
*         WHERE
*          IPHASE IS A PHASE CODE FROM 0 TO 31
*          OR -1 IF PREVIOUS VALUE IS TO BE USED
*          IATTN IS AN ATTENUATOR CONTROL CODE
*          FROM 0 TO 7 OR -1 IF PREVIOUS VALUE
*          IS TO BE USED
*
*
*****************************************************************
*
*      SET CONTROL CARD ADDRESSES
*
IPD    EQU 51B
       DEF IPHS
       DEF IO1
       DEF IO2
       DEF IO3
*
IPHS   NOP              PHASE WORD ADDRESS
IAMP   NOP              AMP. WORD ADDRESS
SETPH  NOP              ENTRY
       JSB .ENTR
       DEF IPHS
       LDA IPHS,I       GET PHASE CODE
       SSA              TEST NEW VALUE
       LDA PHAS         NO, USE OLD
       AND MM37         MASK
       STA PHAS         SAVE
       ALS,ALS          SHIFT
       ALS
       STA TMP
       LDA IAMP,I       GET AMP CODE
       SSA              NEW VALUE?
       LDA AMP          NO, LOAD OLD
       AND MM3          MASK
       STA AMP          SAVE
       IOR TMP          COMBINE AMP AND PHASE
IO1    OTA IPD          OUTPUT
IO2    STC IPD,C        STROBE
IO3    CLC IPD,C        TURN OFF STROBE
       JMP SETPH,I      EXIT
*
*
```

```
MM37    OCT 037
MM3     OCT 03
AMP     BSS 1
PHAS    BSS 1
TMP     BSS 1
*
*
        END
```

```
       HED  POWER LEVELING LOOP ROUTINES
       NAM SIGDR
       ENT INITP,SETPW,PLOFF,PLRST
       EXT .ENTR,.DLD,.FMP,IFIX
       EXT  .DIV,.MPY,SRFLR
       SPC 1
*************************************************************
*
*      SIGNAL GENERATOR DRIVER FOR USE WITH
*      S.A. TEST RACK.
*
*      CALLING SEQUENCES
*            CALL INITP (POWER)
*            CALL SETPW (POWER)
*            CALL PLOFF (VOLTS)
*            CALL PLRST
*
*      WHERE POWER IS THE DESIRED LOOP LEVEL
*      IN DBM, AND VOLTAGE IS DESIRED VOLTAGE
*      SETTING OF THE DVS.  POWER MUST BE IN
*      THE RANGE +5.0 DBM TO +23.0 DBM, AND
*      VOLTS MUST LIE BETWEEN -16.0 AND +16.0.
*      INITP INITIALIZES THE POWER LEVELING LOOP
*      AND SETPW ALLOWS THE CHANGING OF THE LOOP
*      LEVEL.  PLOFF DISABLES THE LOOP AND SETS
*      THE DVS TO THE DESIRED VOLTAGE.  PLRST
*      REARMS THE LOOP, USING THE PREVIOUS
*      POWER LEVEL AND VOLTAGE.  ALL ENTRIES
*      SET BOTH PERF (POWER ERROR FLAG) AND
*      OFRF (OUT OF RANGE FLAG) TO 1.
*
*
*      M.B.LAING      MODIFIED 3/29/77
*
*
*************************************************************
       SPC  1
*      DEFINE POWER METER, DVS, AND STATUS PANEL SELECT SLOTS
       SPC  1
PMS    EQU  14B
DVS    EQU  17B
FLAGR  EQU  50B
       SPC  1
       DEF  IPWR
       DEF  IO1
       DEF  IO2
       DEF  IO3
       DEF  IO4
       DEF  IO5
       DEF  IO6
       DEF  IO7
       DEF  IO8
       DEF  IO9
       DEF  IO9A
       DEF  IO10
       DEF  IO11
       DEF  IO12
       DEF  IO13
```

```
        DEF   IO14
        DEF   IO15
        DEF   IO16
        SKP
IPWR    BSS 1
INITP   NOP             ENTRY POINT FOR INITIALIZATION
        JSB .ENTR
        DEF IPWR
IO1     CLC PMS,C       DISABLE INTERUPT
        JSB GPTL        GET POWER LEVEL
        STA IDBMD       SET LEVEL
        STA LPR
        JSB .MPY        GET VOLTAGE
        DEF VCF
        JSB TVOLT       LIMIT TO +-5.0
        STA VOFST       SAVE
        JSB VOUT        SET VOLTAGE
        CLA
        STA VC
        LDA IJSB
IO2     STA PMS         SET TRAP
        JSB SFB         SET ERROR FLAGS
        STC 0           ARM INTERUPT SYSTEM
IO3     STC PMS,C       ARM POWER METER
        JMP INITP,I     EXIT
IJSB    JSB LINK,I
        ORB
LINK    DEF CONT        SET UP LINK
        ORR
IPWR1   BSS  1
SETPW   NOP
        JSB .ENTR       ENTRY POINT
        DEF  IPWR1
        LDA  IPWR1
        STA  IPWR
        JSB GPTL        GET POWER
        STA IDBMD       SET LEVEL
        JSB SFB         SET ERROR FLAGS
        JMP SETPW,I     EXIT
        SKP
IVLT    BSS 1
PLOFF   NOP             ENTRY LOOP OFF
        JSB .ENTR
        DEF IVLT
IO4     CLC PMS,C       DISARM LOOP
        CLA
IO5     STA PMS         CLEAR TRAP
        JSB .DLD        GET VOLTAGE
        DEF IVLT,I
        JSB .FMP
        DEF D2000       SCALE TO INTEGER
        JSB IFIX
        STA 1
        ADB HVLIM       LIMIT TO 16 VOLT RANGE
        SSB
        LDA LVLIM
        LDB 0
        ADB LVLIM
```

```
        SSB,RSS
        LDA HVLIM
        JSB VOUT        OUTPUT VOLTAGE
        JSB SFB         SET ERROR FLAGS
        JMP PLOFF,I
PLRST   NOP             ENTRY TO RESET LOOP
        ISZ PLRST
        LDA VOFST       GET LAST VOLTAGE
        JSB VOUT        OUTPUT VOLTAGE
        JSB SFB         SET ERROR FLAGS
        LDA IJSB        SET TRAP
I06     STA PMS
        STC 0           ARM INTERUPT
I07     STC PMS,C       ARM POWER METER
        JMP PLRST,I     EXIT
        SKP
CONT    NOP             ENTRY POINT FOR LOOP
I08     CLC PMS,C       DISARM INTERUPT
        STA AR          SAVE REGISTERS
        STB BR
        ERA,ALS
        OCT  102201      OCT FOR SOC
        INA
        STA ER
I09     LIA PMS         READ POWER METER
        CMA
        LDB D13         SET FOR 13 BITS
        JSB BCDTB       CONVERT TO BINARY
        CMA,INA         GET CORRECT SIGN
        STA POWER       SAVE
        CPA IDBMD       COMPARE TO LEVEL
        JMP EXACT       GOOD LEVEL
        STA 1
I09A    LIA  FLAGR
        AND B4
        SZA
        JMP *+8
        LDA 1
        ADA D200        TEST FOR OUT OF RANGE
        SSA
        JMP OFR
        ADB M100        LIMITS OF -20 TO +10
        SSB,RSS
        JMP OFR
        LDA OFRF        RESET OFRF BIT
        CMA
        CLB
        JSB  SFLAG .     RESET BIT
NVCF    LDA POWER
        CMA,INA
        ADA IDBMD       GET ERROR
        STA PWER        SAVE
        JSB .MPY        NEW VC
        DEF VCF
        SSA
        ARS             DIVIDE BY 2 IF NEG.
        STA VC
        LDA PWER
```

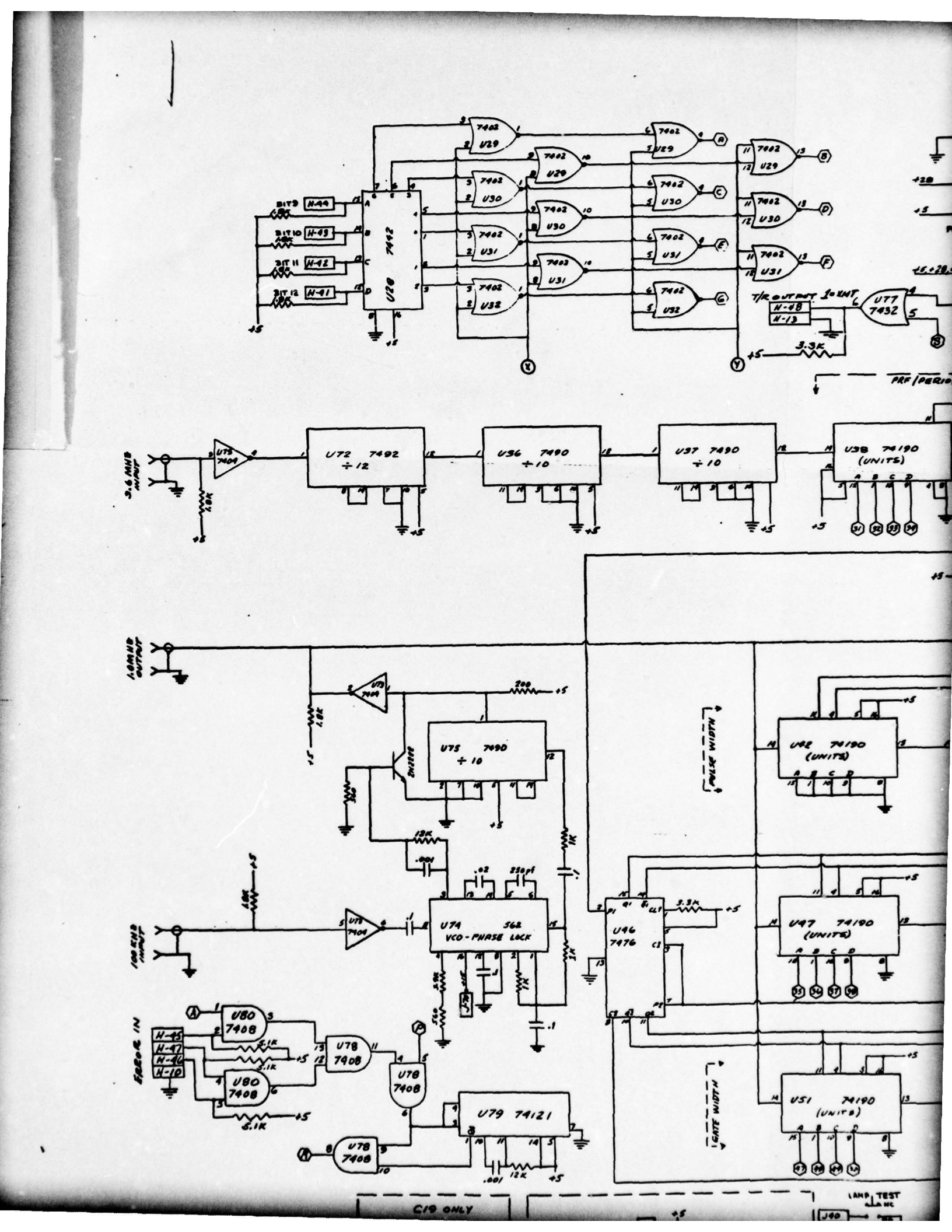
```
        SSA             ABSOLUTE VALUE
        CMA,INA
        ADA PLEL        MINUS LIMIT
        CLS
        SSA,RSS
        LDB PEF
        LDA PEF
        CMA
        JSB  SFLAG       SET ERROR BIT
        LDA VC
        ADA VOFST       NEW VOLTAGE
        JSB TVOLT       TEST FOR LIMITS
        STA VOFST
        JSB VOUT        OUTPUT VOLTAGE
EXIT    LDB BR          RESTORE REGISTERS
        LDA ER
        CLO
        SLA,ELA
        STO
        LDA AR
I010    STC PMS,C       ARM POWER METER
        JMP CONT,I      EXIT
OFR     LDA  PEF         OUT OF RANGE
        ADA  OFRF
        STA  1
        CMA
        JSB  SFLAG       SET ERROR BITS
        JMP EXIT
EXACT   LDA PEF
        ADA OFRF
        CMA
        CLB
        JSB  SFLAG       SET FLAGS GOOD
        JMP EXIT
        SKP
SFB     NOP             SET BAD
        LDA PEF
        ADA OFRF
        STA 1
        CMA
        JSB SRFLR
        JMP SFB,I
        SPC 2
GPTL    NOP             ENTRY, GET AND TEST POWER
        JSB .DLD
        DEF IPWR,I
        JSB .FMP
        DEF D10.0
        JSB IFIX
        STA 1
        ADB D150        TEST FOR -15 TO +3 RANGE
        SSB
        LDA M150
        LDB 0
        ADB M30
        SSB,RSS
        LDA D30
        JMP GPTL,I      EXIT
```

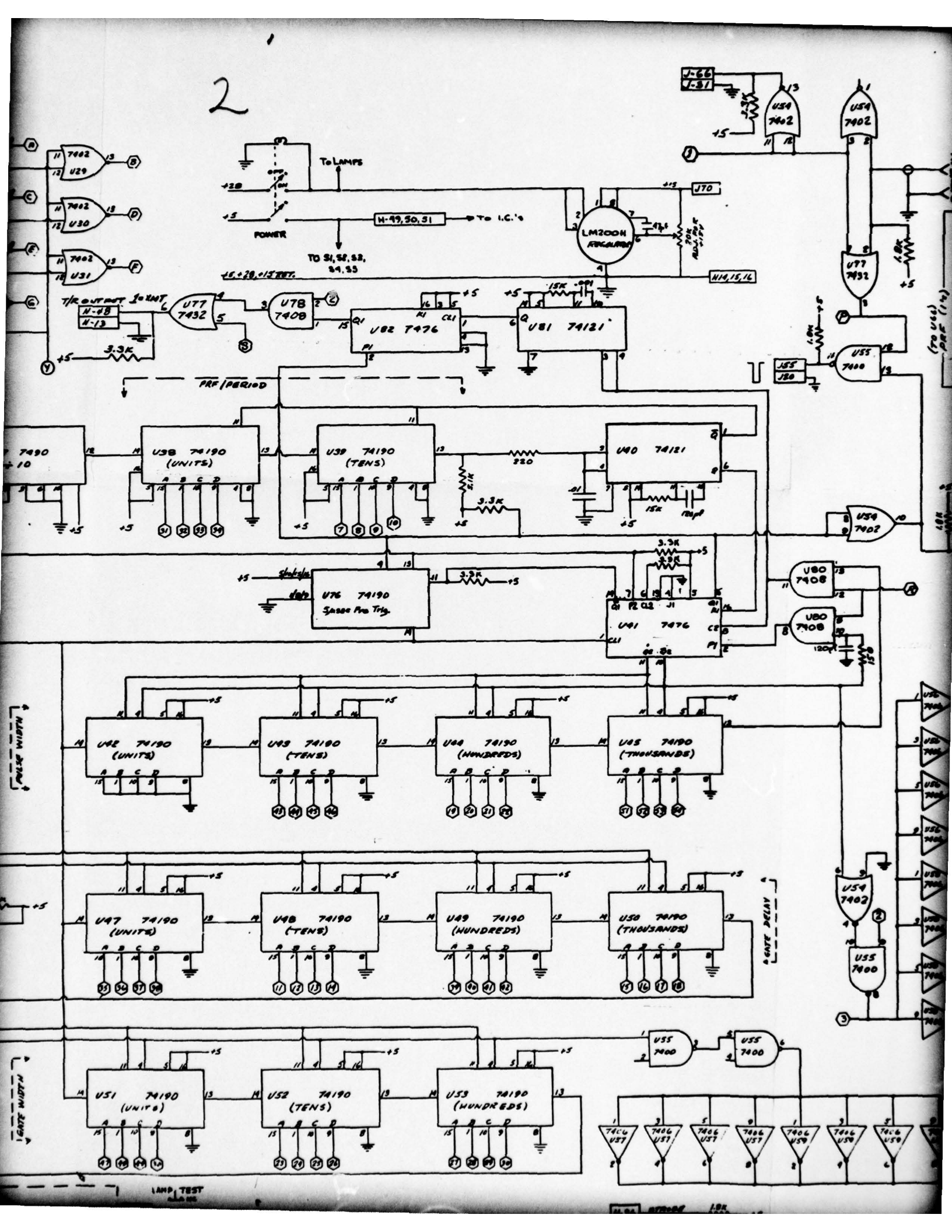
```
        SKP
TVOLT   NOP  ENTRY TEST VOLTAGE
        STA  VLTS       SAVE
        STA  1
        ADB  VHLIM
        SSB
        LDA  VLLIM
        LDB  0
        ADB  VLLIM
        SSB,RSS
        LDA  VHLIM
        CPA  VLTS       TEST FOR CHANGE
        JMP  TVOLT,I    GOOD, EXIT
        LDB  VLTS
        CMB,INB
        ADB  0
        ADB  VC
        STB  VC         SET NEW VOLTAGE CHANGE
        JMP  TVOLT,I
        SPC  2
VOUT    NOP             ENTRY, OUTPUT VOLTAGE
        LDB  WRD2
IO11    CLC  DVS,C
IO12    OTA  DVS
IO13    OTB  DVS
        LDB  M625
IO14    SFC  DVS        WAIT TILL DONE
        JMP  VOUT,I
        INB,SZB
        JMP  *-3
        JMP  VOUT+1
        SPC  2
*       DATA AND STORAGE
        SPC  2
VCF     DEC  20
D2000   DEC  2000.002
HVLIM   DEC  16000
LVLIM   DEC  -16000
D13     DEC  13
D200    DEC  200
M100    DEC  -100
PEF     DEC  1
OFRF    DEC  2
D10.0   DEC  10.0
D150    DEC  150
M150    DEC  -150
D30     DEC  30
M30     DEC  -30
VHLIM   DEC  10000
VLLIM   DEC  -10000
PLEL    DEC  -2
WRD2    OCT  0100
M625    DEC  -625
B4      OCT  4
IDBMD   BSS  1
LPR     BSS  1
VOFST   BSS  1
VC      BSS  1
```

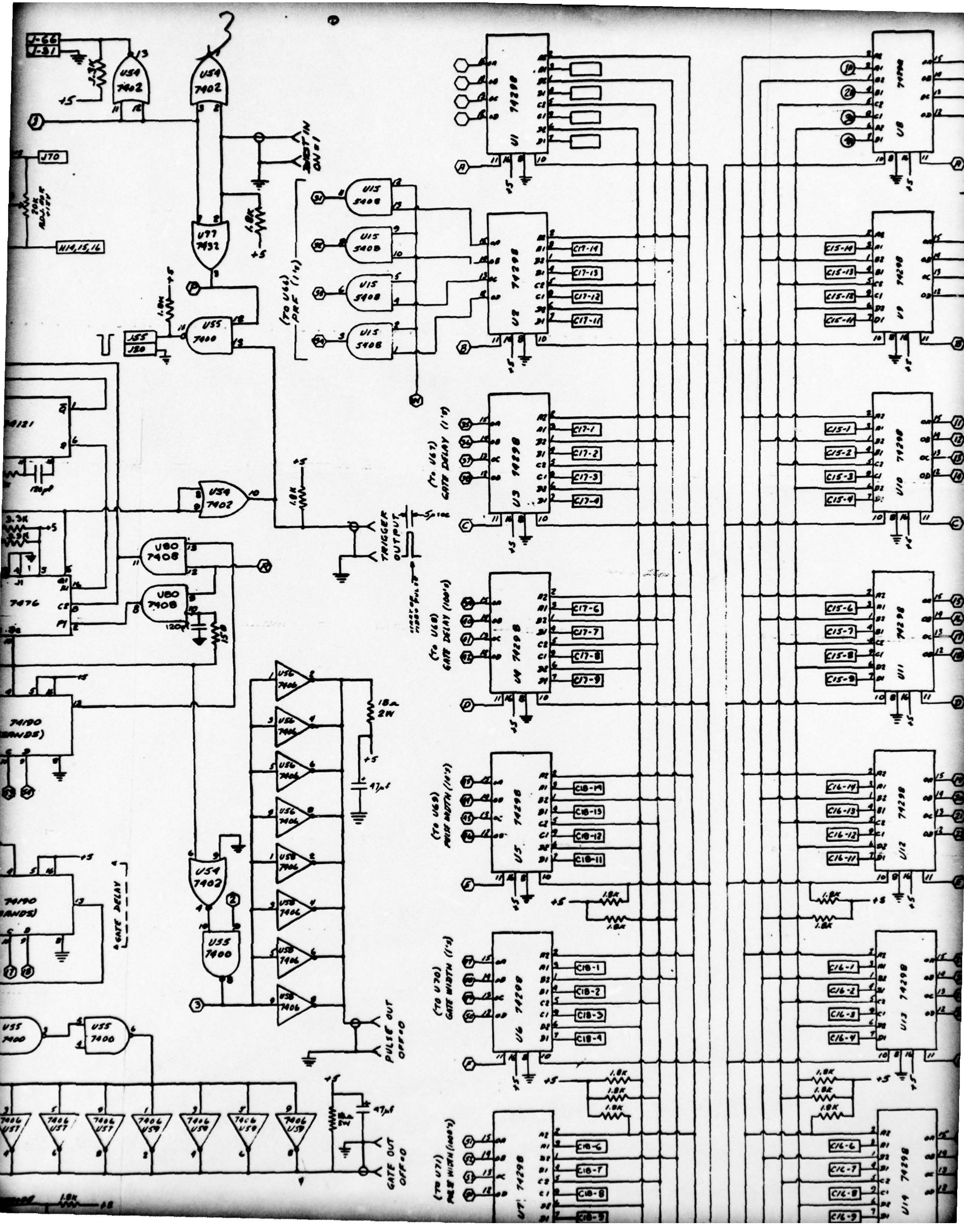
```
AR      BSS 1
BR      BSS 1
ER      BSS 1
POWER   BSS 1
PWER    BSS 1
VLTS    BSS 1
BCDTB   NOP
        CMB,INB
        STB CTR
        LDB DTABL
        STB PTR
        CLB
LOOP    SLA
        ADB PTR,I
        CLE,ERA
        ISZ PTR
        ISZ CTR
        JMP LOOP
        SLA
        CMB,INB
        LDA 1
        JMP BCDTB,I
TABLE   DEC 1,2,4,8,10,20,40,80,100,200,400,800
        DEC 1000,2000,4000,8000
DTABL   DEF TABLE
PTR     BSS 1
CTR     BSS 1
SFLAG   NOP             ENTRY
        STA  TMPSR
IO15    LIA  FLAGR
        AND  TMPSR
        ADA  1
IO16    OTA  FLAGR
        JMP  SFLAG,I    EXIT
TMPSR   BSS  1
        END
```

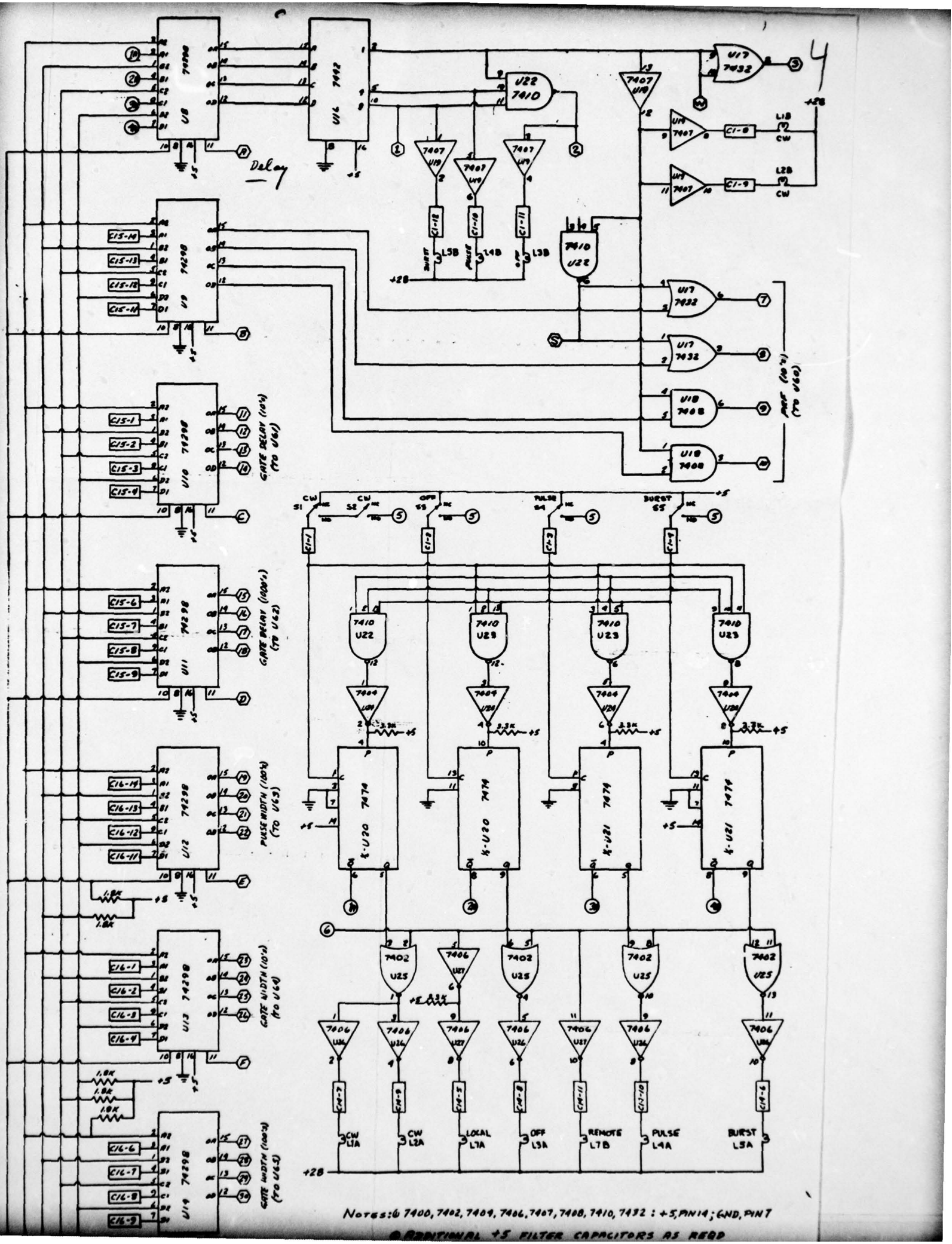
APPENDIX IV

Schematics of hardware designed at NRL specially tailored towards L-band transceiver test.


BIT 9 H-44
BIT 10 H-43
BIT 11 H-42
BIT 12 H-41
U28 7492
7402 U29
7402 U30
7402 U31
7402 U32
T/R OUTPUT 1.0 KHZ
H-48
H-13
U77 7432
3.3K
PRF PERIOD
3.6 MHZ INPUT
U72 7492 ÷ 12
U36 7490 ÷ 10
U37 7490 ÷ 10
U38 74190 (UNITS)
1.0 MHZ OUTPUT
U73 7404
U75 7490 ÷ 10
2N2222
U74 562 VCO-PHASE LOCK
100 KHZ INPUT
U82 74190 (UNITS)
U46 7476
U47 74190 (UNITS)
PULSE WIDTH
U51 74190 (UNITS)
GATE WIDTH
ERROR IN
U80 7408
U78 7408
U79 74121
C19 ONLY
LAMP TEST


2
To LAMPS
POWER
TO S1, S2, S3, S4, S5
H-49, 50, 51
To I.C.'s
LM200H REGULATOR
J70
H14, 15, 16
T/R OUTPUT
H-48
H-13
PRF PERIOD
U38 74190 (UNITS)
U39 74190 (TENS)
U40 74121
U76 74190 Space Pre Trig.
U81 74121
U82 7476
U91 7476
U42 74190 (UNITS)
U43 74190 (TENS)
U44 74190 (HUNDREDS)
U45 74190 (THOUSANDS)
U47 74190 (UNITS)
U48 74190 (TENS)
U49 74190 (HUNDREDS)
U50 74190 (THOUSANDS)
U51 74190 (UNITS)
U52 74190 (TENS)
U53 74190 (HUNDREDS)
GATE DELAY
GATE WIDTH
LAMP TEST

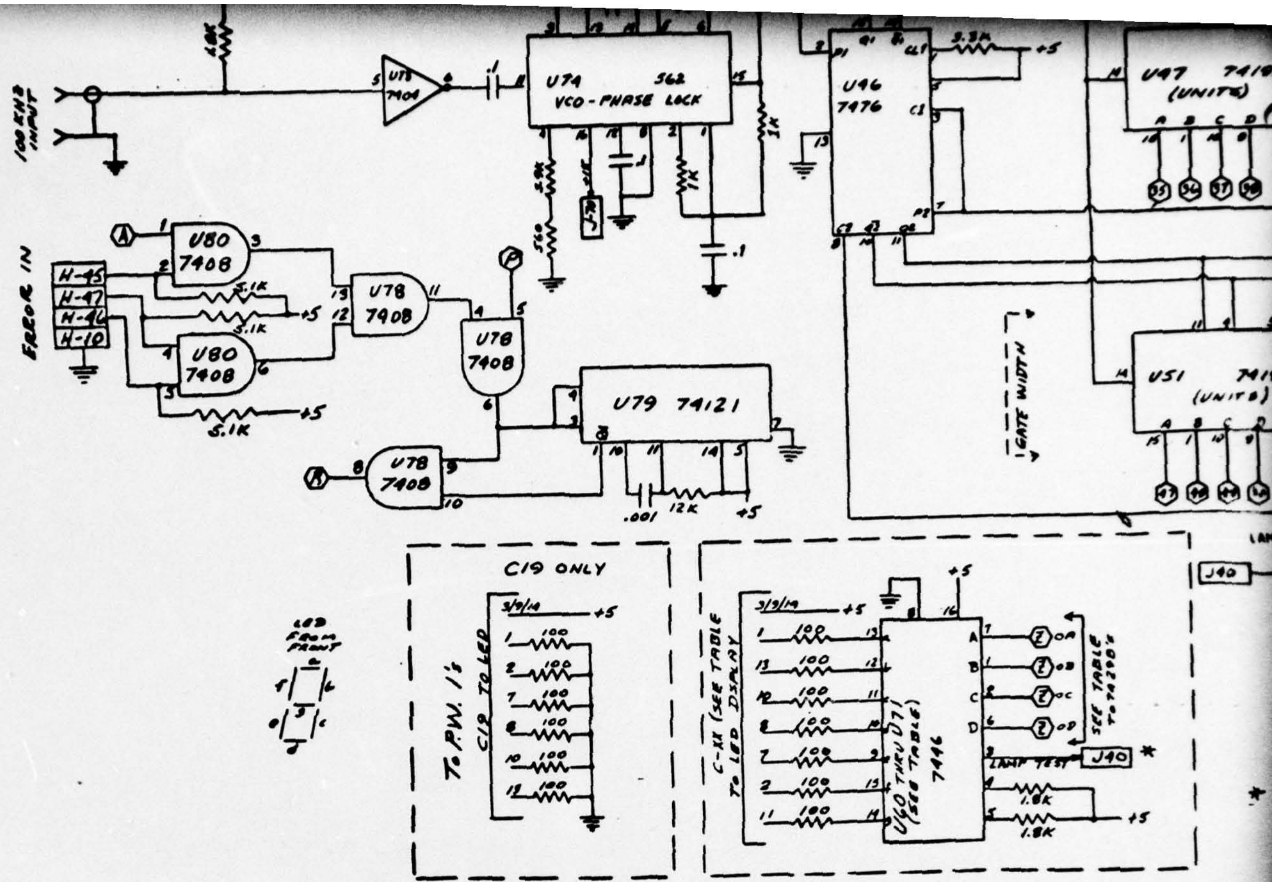

TRIGGER OUTPUT
PULSE OUT OFF=0
GATE OUT OFF=0
GATE DELAY
74298
74190
7476
7400
7402
7406
7408
5408
7432

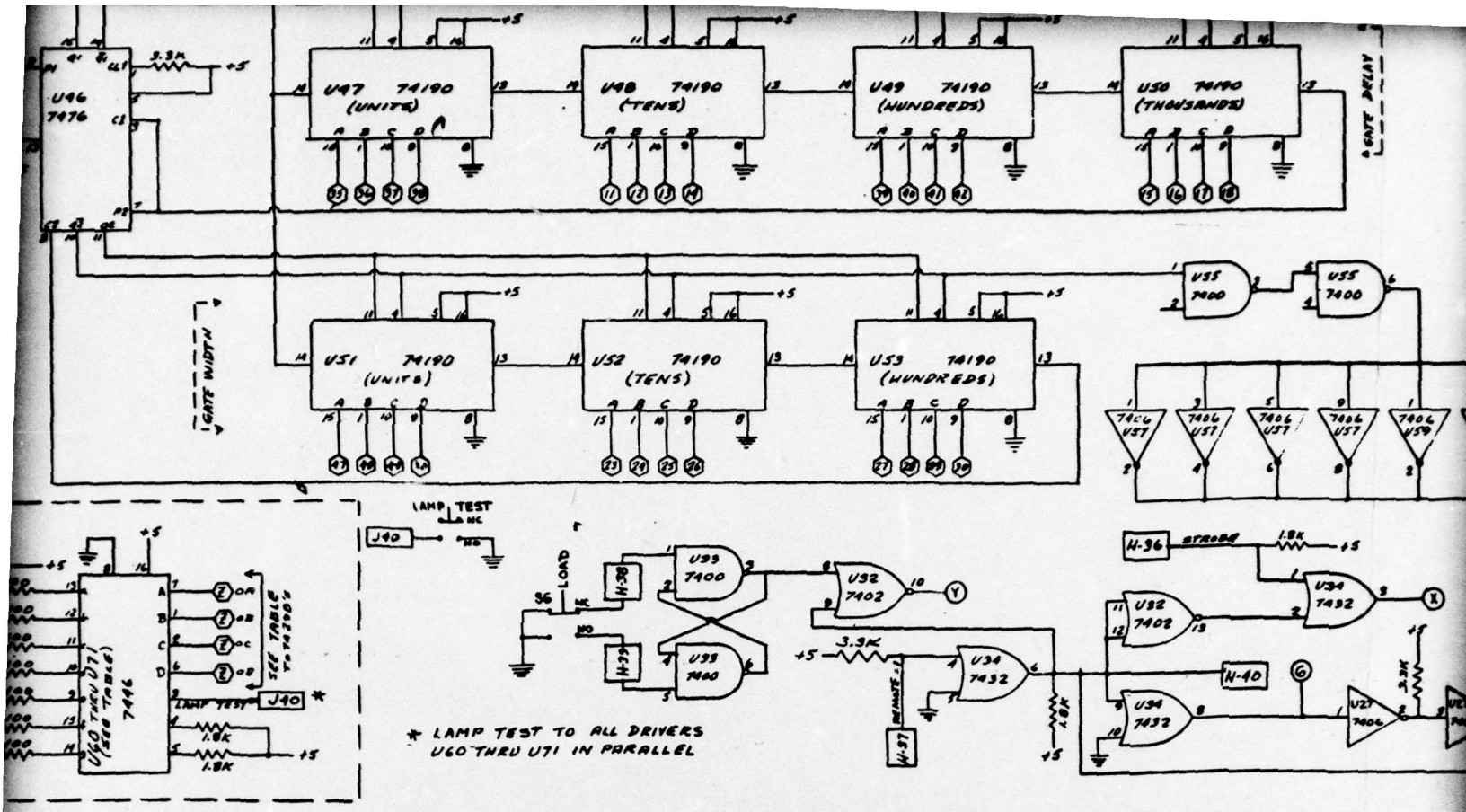


NOTES: ① 7400, 7402, 7404, 7406, 7407, 7408, 7410, 7432 : +5, PIN 14 ; GND, PIN 7

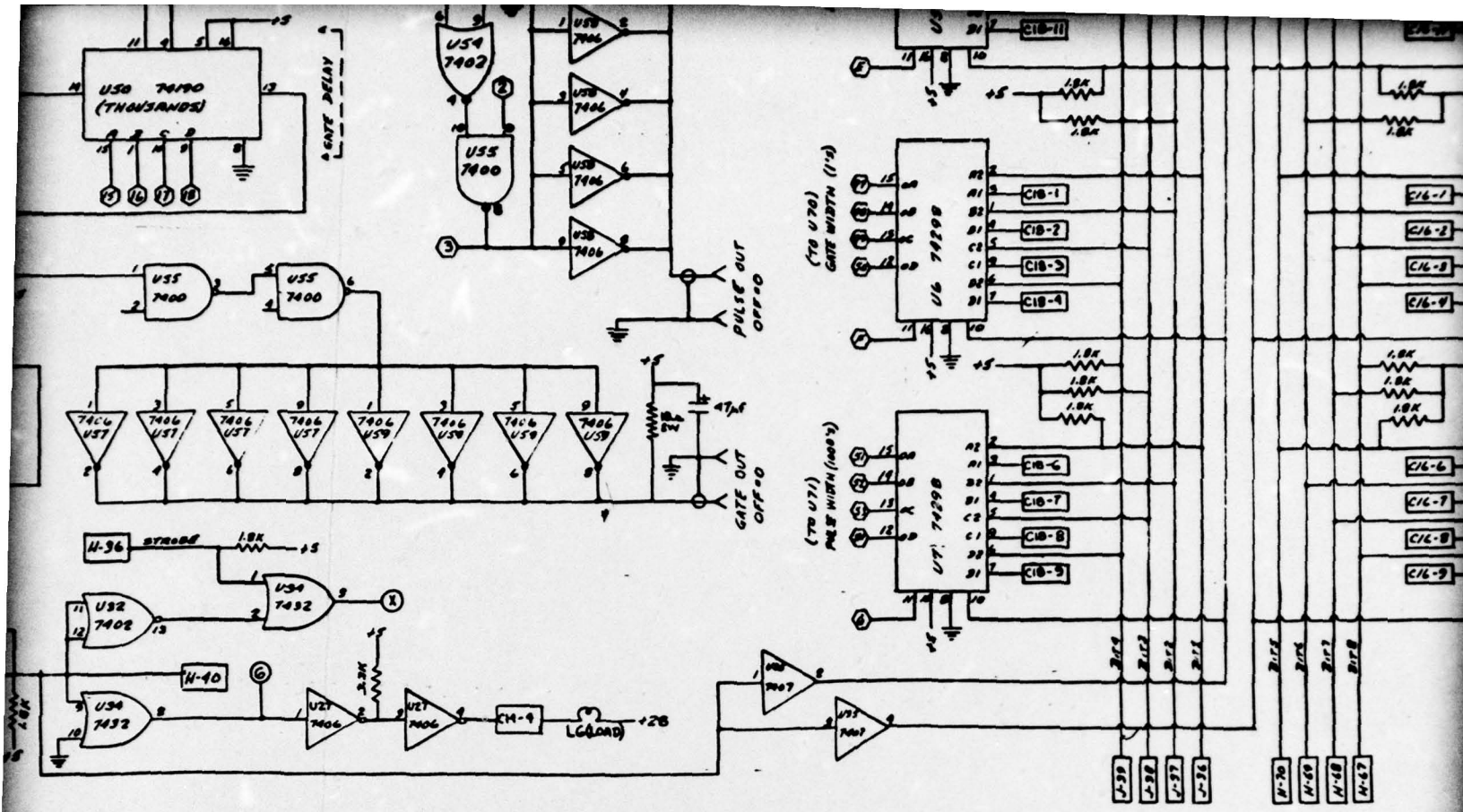
② OPTIONAL +5 FILTER CAPACITORS AS REQD

5


100 KHZ INPUT
U74 562
VCO - PHASE LOCK
U46
7476
U47
(UNITS)
ERROR IN
H-45
H-47
H-10
U80
7408
U78
7408
5.1K
+5
U79 74121
.001
12K
GATE WIDTH
U51
(UNITS)
J40
C19 ONLY
To P.W. 1's
C19 TO LED
100
C-XX (SEE TABLE
To LED DISPLAY
U60 THRU U71
(SEE TABLE)
7446
A
B
C
D
SEE TABLE
LAMP TEST
1.8K
LED
FROM FRONT


U46 7476
3.3K
+5
U47 74190 (UNITS)
U48 74190 (TENS)
U49 74190 (HUNDREDS)
U50 74190 (THOUSANDS)
GATE DELAY
PULSE WIDTH
U51 74190 (UNITS)
U52 74190 (TENS)
U53 74190 (HUNDREDS)
U55 7400
U55 7400
7406 U57
7406 U57
7406 U57
7406 U57
7406 U59
LAMP TEST
J40
U60 THRU U71 (SEE TABLE)
7447
SEGMENT DRIVE TABLE
1.8K
LOAD
SG
H-38
H-39
U33 7400
U33 7400
U32 7402
3.9K
U34 7432
H-37
H-36
STROBE
U32 7402
U34 7432
H-40
U34 7432
U27 7404
* LAMP TEST TO ALL DRIVERS U60 THRU U71 IN PARALLEL

6



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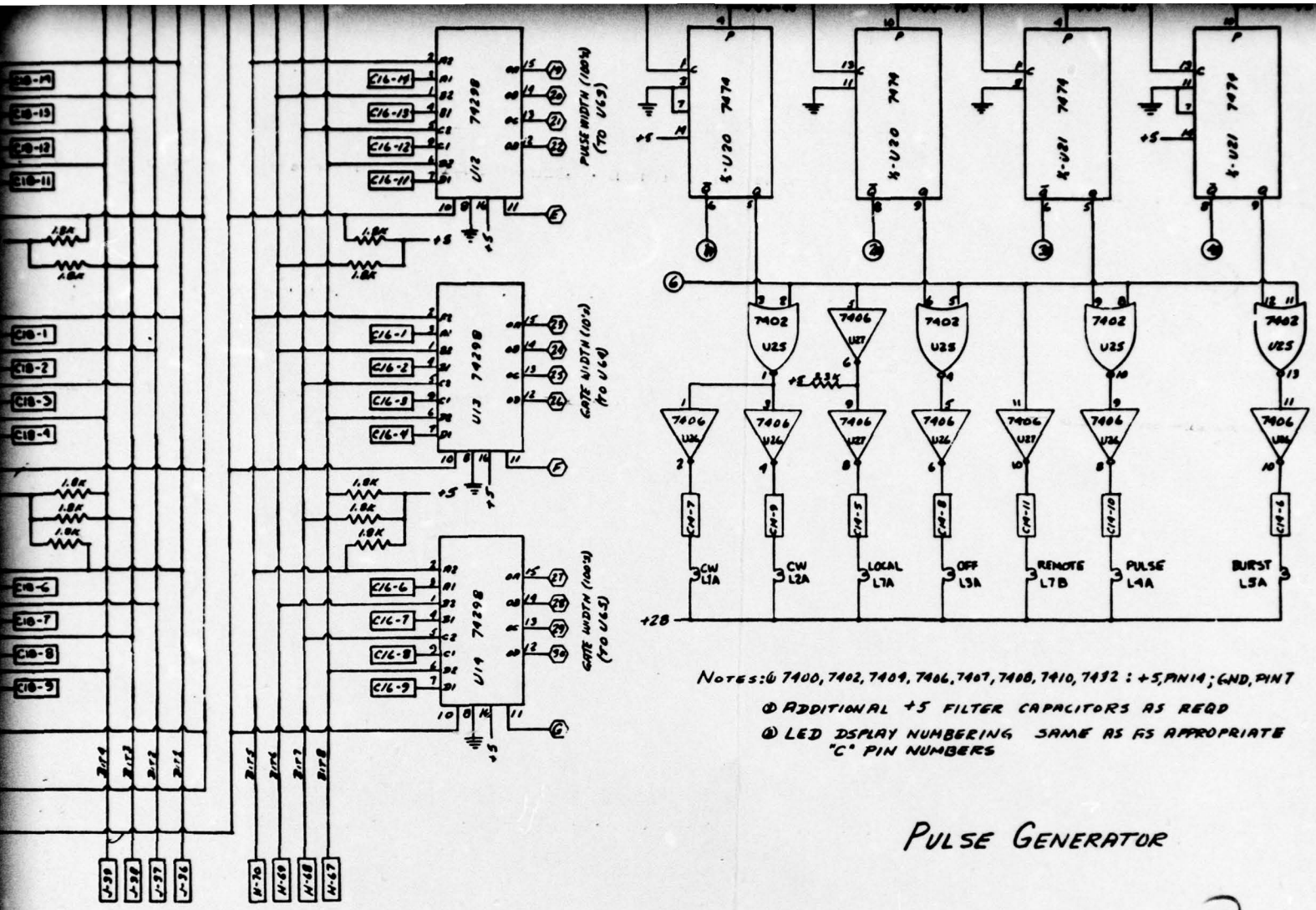


NOTES: ① 7400, 7402, 7404, 7406, 7407, 7408, 7410, 7432 : +5, PIN 14; GND, PIN 7

② ADDITIONAL +5 FILTER CAPACITORS AS REQD

③ LED DISPLAY NUMBERING SAME AS FS APPROPRIATE "C" PIN NUMBERS

PULSE GENERATOR

TABLE 1 LED DSPLAY

U#	INPUTS A	B	C	D	FROM	OUTPUTS TO	VIA
U-61	11	12	13	14	U-10	G.D. 10's	C-3
U-62	15	16	17	18	U-11	G.D.1000's	C-4
U-63	19	20	21	22	U-12	P.W. 100's	C-5
U-64	23	24	25	26	U-13	G.W. 10's	C-6
U-65	27	28	29	30	U-14	G.W. 100's	C-7
U-66	31	32	33	34	U-15	PRF 1's	C-13
U-67	35	36	37	38	U-3	G.D. 1's	C-12
U-68	39	40	41	42	U-4	G.D. 100's	C-11
U-69	43	44	45	46	U-5	P.W. 10's	C-10
U-70	47	48	49	50	U-6	G.W. 1's	C-9
U-71	51	52	53	54	U-7	P.W 1000's	C-8
U-60	7	8	9	10	U47&U48	PRF 10's	C-2

COMPUTER INPUTS

(1)	BITS (2)	(4)	(8)	(1)(2)(4)(8)	(1)(2)(4)(8)
9	10	11	12	1,2,3,4	5,6,7,8
0	0	0	0	P.W 10's	P.W 100's
1	0	0	0	G.W 1's	G.W 10's
0	1	0	0	P.W 1000's	G.W 100's
1	1	0	0	G.D. 1's	G.D 10's
0	0	1	0	G.D 100's	G.D 1000's
1	0	1	0	PRF 1's	PRF 10's
0	1	1	0	XXXX	SEE MODE TABLE

MODE INPUTS

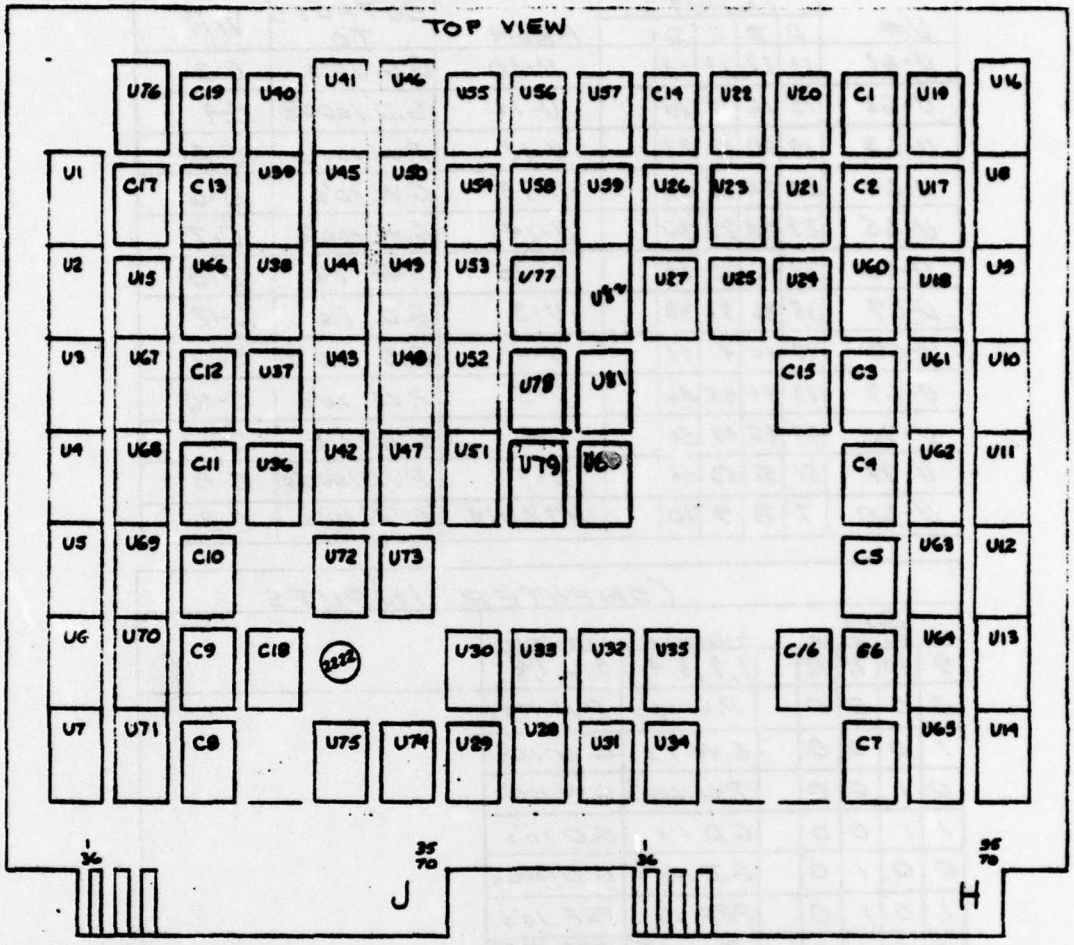
BITS 5	6	7	8	MODE FUNCTION
0	0	0	1	BURST
0	1	0	0	OFF
0	0	1	0	PULSE
1	0	0	0	CW

WITH BITS 9,10,11,12 SET AS ABOVE

NOTES:
1. FOR CW: TRIGGER OUTPUT COUNTS DOWN BY 30
   TRIGGER PRF=100
2. ALL OTHER THAN BURST-PULSE-CW YIELDS OFF

Pulse Generator (Continued)

CIRCUIT BOARD



Note: Connectors C1-18 notch end (yellow/orange wires) is Pin 1 end.

COMPUTER CONNECTOR

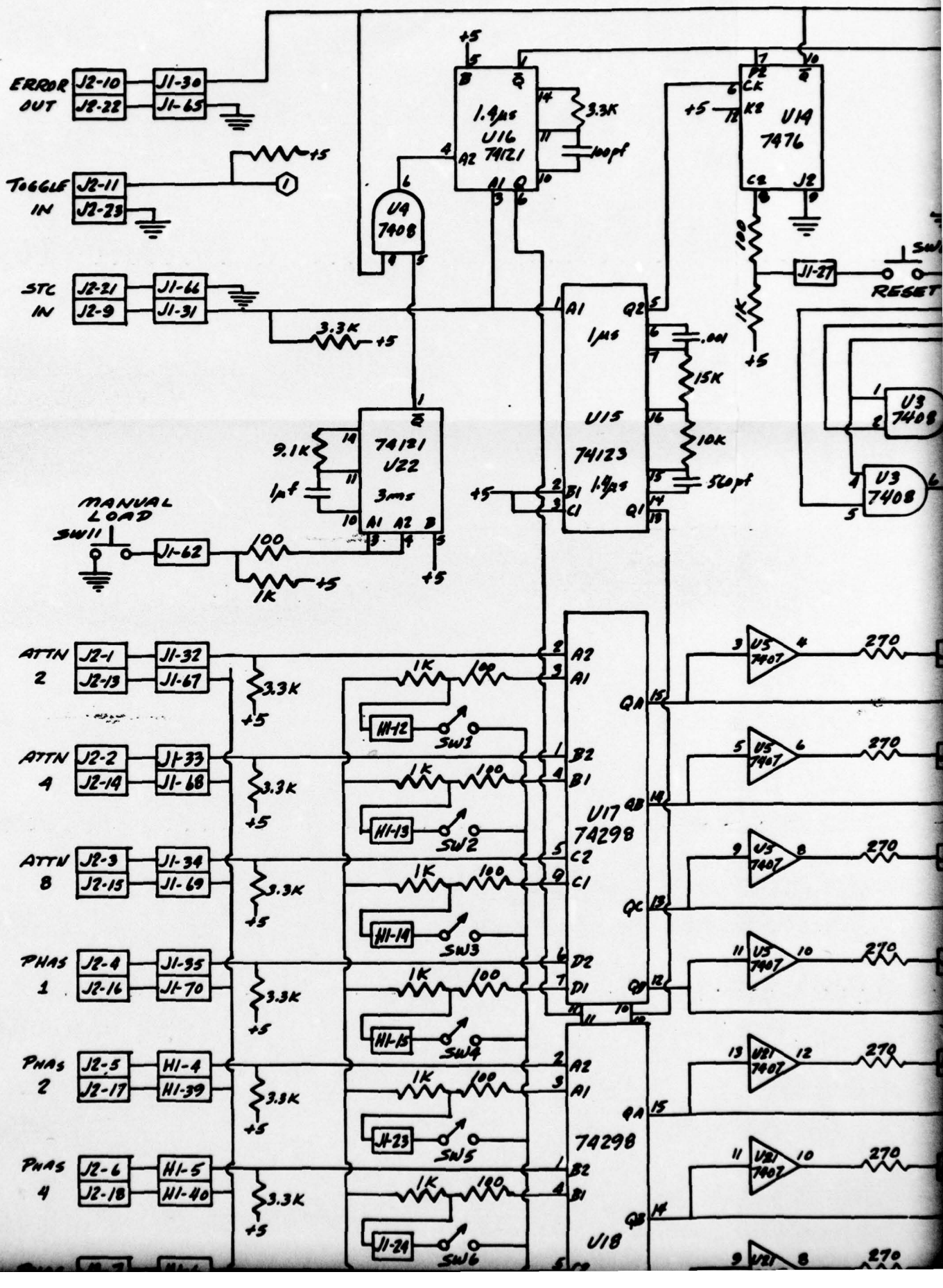
Pin	Function	To
19	BIT 1	J-36
20	BIT 2	J-37
21	BIT 3	J-38
22	BIT 4	J-39
27	BIT 9	H-44
28	BIT 10	H 43
35	Local/Remote Resist	H-37
34	Burst Logic Out Burst = 1	J-62
33	Trig. Out Burst	J-55
14	Error In	H-45
13	Error In	H-46
32	Error In	H-47
31	Trig. In - Out	H-48

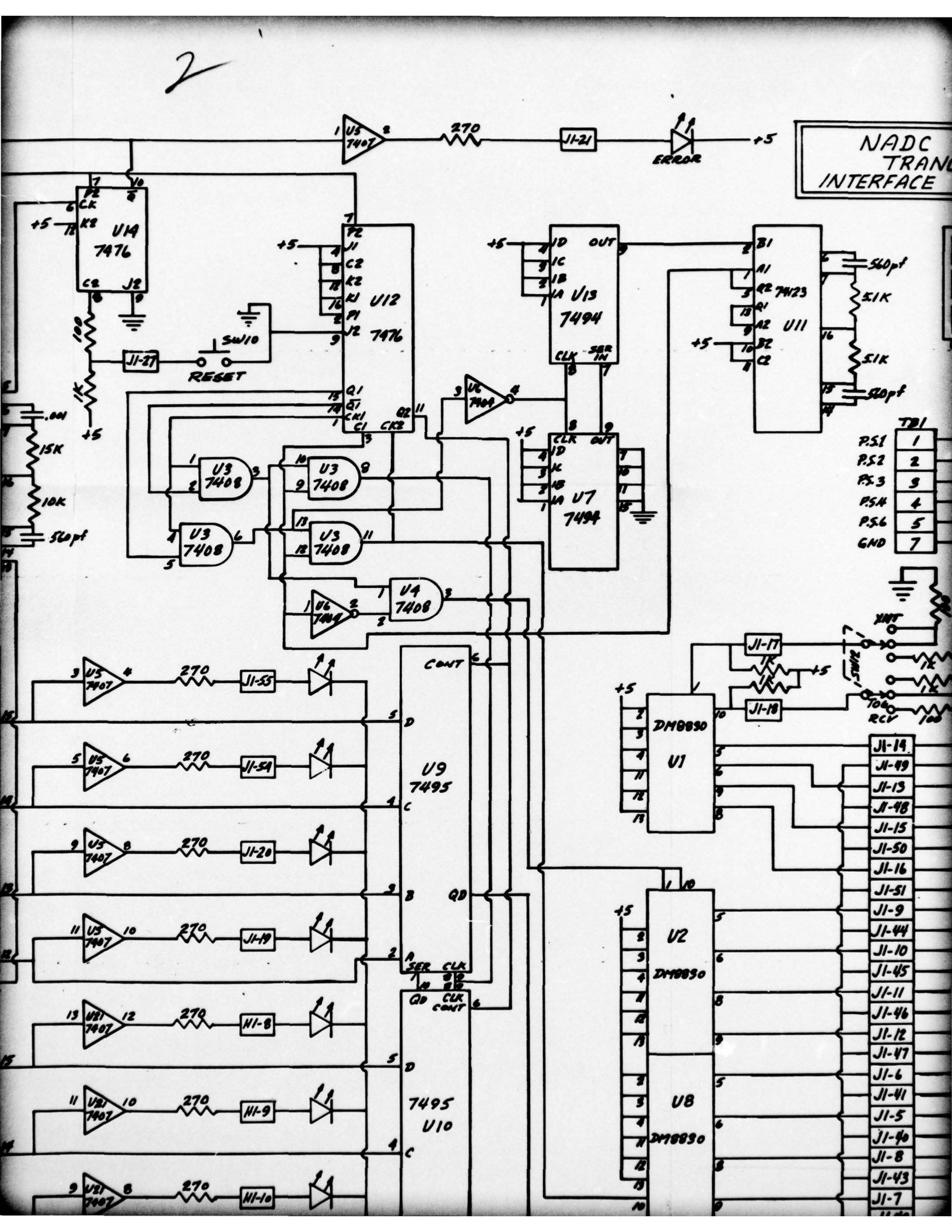
All grounds tied to pin 18 on computer connector

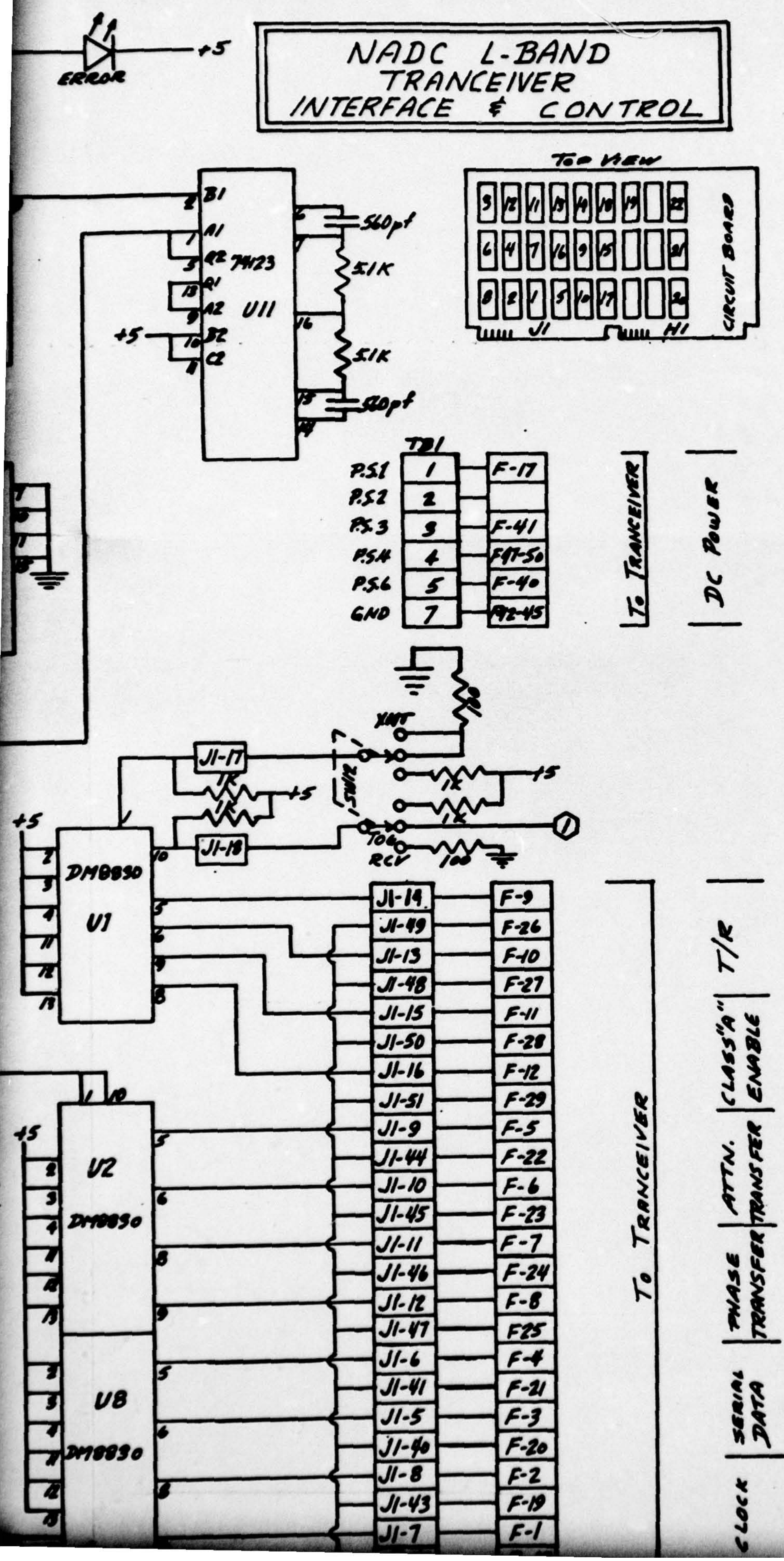
Pin	Function	To
23	Bit 5	H-70
24	Bit 6	H-69
25	Bit 7	H-68
26	Bit 8	H-67
29	Bit 11	H-42
30	Bit 12	H-41
36	Strobe	H-36

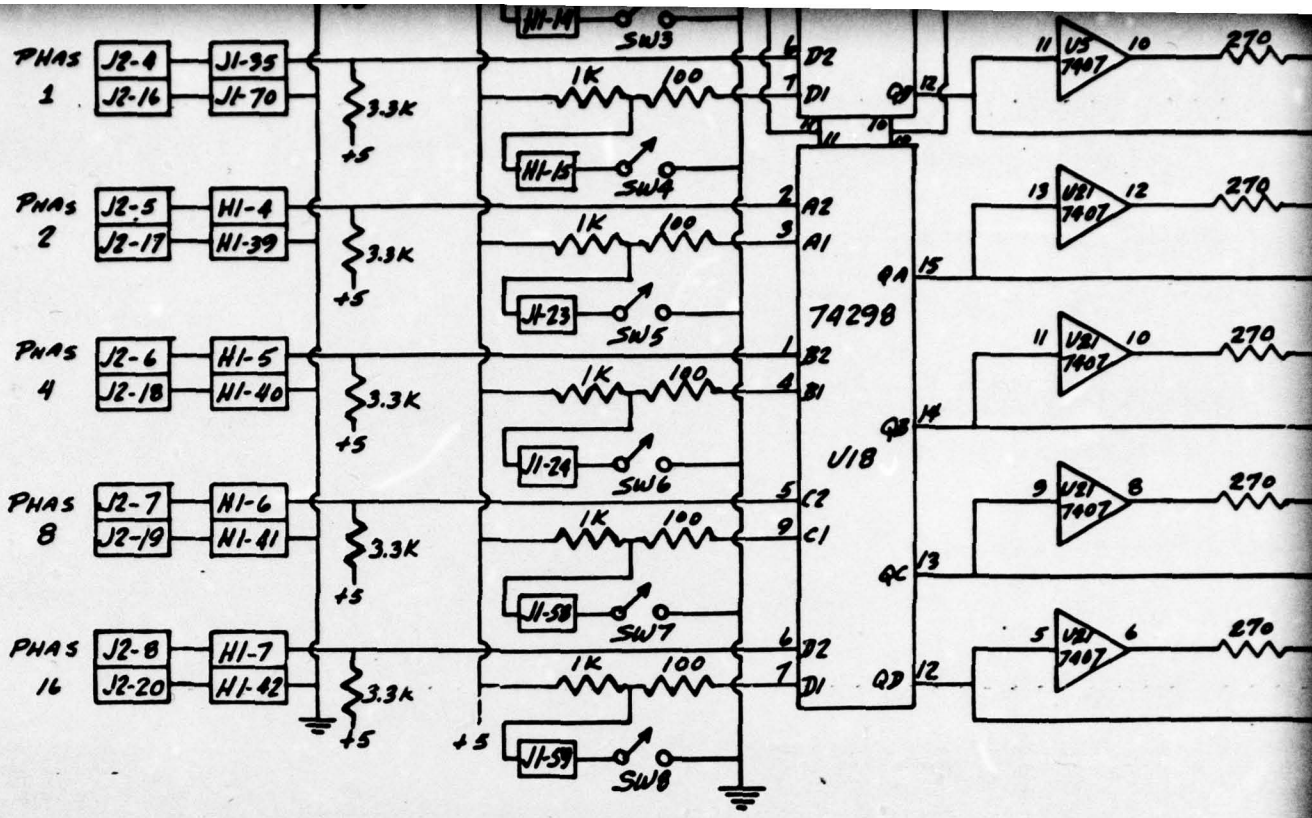
All grds pin 18 on computer connector

TP = Twisted Pair

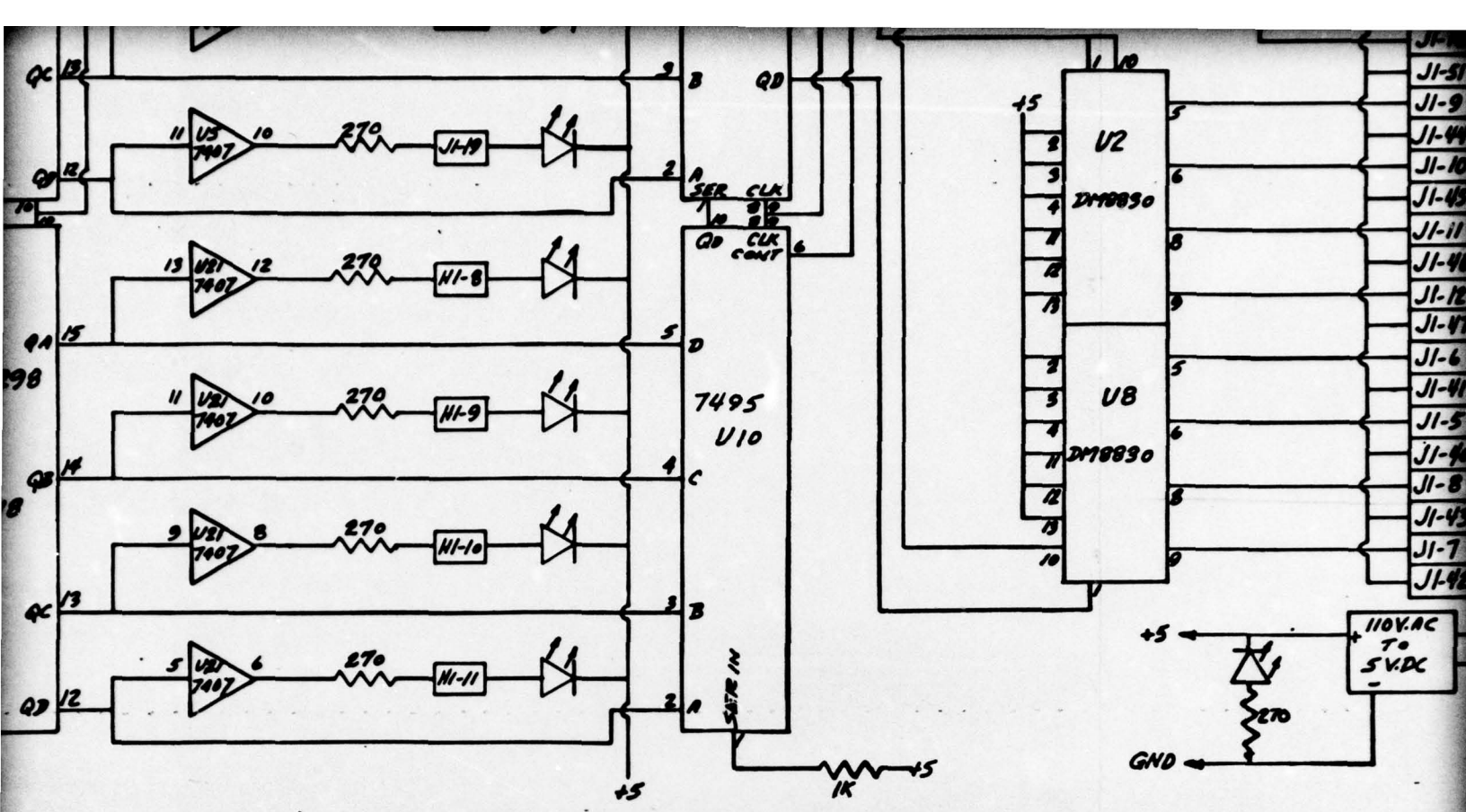

ERROR OUT
J2-10
J2-22
J1-30
J1-65
TOGGLE IN
J2-11
J2-23
STC IN
J2-21
J2-9
J1-66
J1-31
MANUAL LOAD
SW11
J1-62
ATTN 2
J2-1
J2-13
J1-32
J1-67
ATTN 4
J2-2
J2-14
J1-33
J1-68
ATTN 8
J2-3
J2-15
J1-34
J1-69
PHAS 1
J2-4
J2-16
J1-35
J1-70
PHAS 2
J2-5
J2-17
H1-4
H1-39
PHAS 4
J2-6
J2-18
H1-5
H1-40
+5
3.3K
1K
100
1.4µs
U16
74121
100pf
U4
7408
9.1K
1µf
3ms
U22
74121
1µs
U15
74123
.001
15K
10K
560pf
1.4µs
U14
7476
RESET
J1-27
U3
7408
U5
7407
270
H1-12
H1-13
H1-14
H1-15
J1-23
J1-24
SW1
SW2
SW3
SW4
SW5
SW6
U17
74298
U18
74298
QA
QB
QC
QD


2
NADC
TRAN
INTERFACE
U5 7407
270
J1-21
ERROR
+5
U14 7476
U12 7476
U13 7494
U7 7494
74123 U11
SW10
RESET
J1-27
100
1K
.001
15K
10K
560pf
5.1K
U3 7408
U4 7408
U6 7404
TB1
P.S.1
P.S.2
P.S.3
P.S.4
P.S.6
GND
XMT
RCV
J1-17
J1-18
DM8830 U1
U2 DM8830
U8 DM8830
U9 7495
U10 7495
CONT
J1-55
J1-54
J1-20
J1-19
H1-8
H1-9
H1-10
J1-14
J1-49
J1-13
J1-48
J1-15
J1-50
J1-16
J1-51
J1-9
J1-44
J1-10
J1-45
J1-11
J1-46
J1-12
J1-47
J1-6
J1-41
J1-5
J1-40
J1-8
J1-43
J1-7


NADC L-BAND
TRANCEIVER
INTERFACE & CONTROL
ERROR
+5
TOP VIEW
J1
H1
CIRCUIT BOARD
74123
U11
560pf
5.1K
5.1K
560pf
TB1
P.S.1
P.S.2
P.S.3
P.S.4
P.S.6
GND
F-17
F-41
F47-50
F-40
F42-45
To TRANCEIVER
DC POWER
XMT
SW2
TOG
RCV
1K
100
J1-17
J1-18
DM8830
U1
U2
U8
J1-14
J1-49
J1-13
J1-48
J1-15
J1-50
J1-16
J1-51
J1-9
J1-44
J1-10
J1-45
J1-11
J1-46
J1-12
J1-47
J1-6
J1-41
J1-5
J1-40
J1-8
J1-43
J1-7
F-9
F-26
F-10
F-27
F-11
F-28
F-12
F-29
F-5
F-22
F-6
F-23
F-7
F-24
F-8
F25
F-4
F-21
F-3
F-20
F-2
F-19
F-1
To TRANCEIVER
T/R
CLASS "A" ENABLE
ATTN. TRANSFER
PHASE TRANSFER
SERIAL DATA
CLOCK


PHAS 1
J2-4
J2-16
J1-35
J1-70
3.3K
+5
J1-14
SW3
1K
100
PHAS 2
J2-5
J2-17
H1-4
H1-39
J1-15
SW4
PHAS 4
J2-6
J2-18
H1-5
H1-40
J1-23
SW5
PHAS 8
J2-7
J2-19
H1-6
H1-41
J1-24
SW6
PHAS 16
J2-8
J2-20
H1-7
H1-42
J1-58
SW7
J1-59
SW8
74298
U18
D2
D1
A2
A1
B2
B1
C2
C1
QA
QB
QC
QD
U3 7407
U21 7407
U21 7407
U21 7407
U21 7407
270

4



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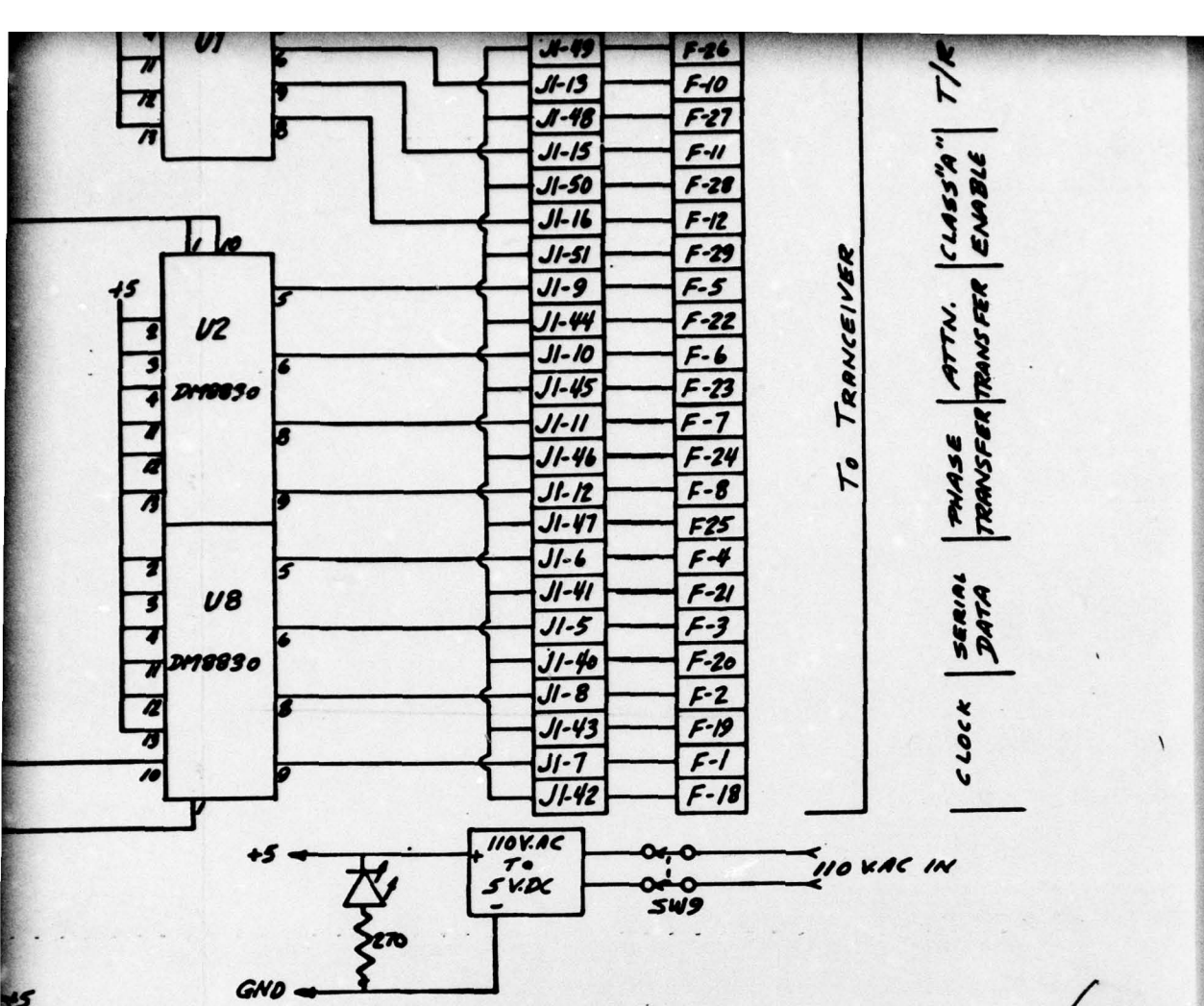
U1
U2
DM8830
U8
DM8830
+5
J1-49
J1-13
J1-48
J1-15
J1-50
J1-16
J1-51
J1-9
J1-44
J1-10
J1-45
J1-11
J1-46
J1-12
J1-47
J1-6
J1-41
J1-5
J1-40
J1-8
J1-43
J1-7
J1-42
F-26
F-10
F-27
F-11
F-28
F-12
F-29
F-5
F-22
F-6
F-23
F-7
F-24
F-8
F25
F-4
F-21
F-3
F-20
F-2
F-19
F-1
F-18
To Tranceiver
CLOCK
SERIAL DATA
PHASE TRANSFER
ATTN. TRANSFER
CLASS "A" ENABLE
T/R
+5
110V.AC TO 5V.DC
110 V.AC IN
SW9
270
GND